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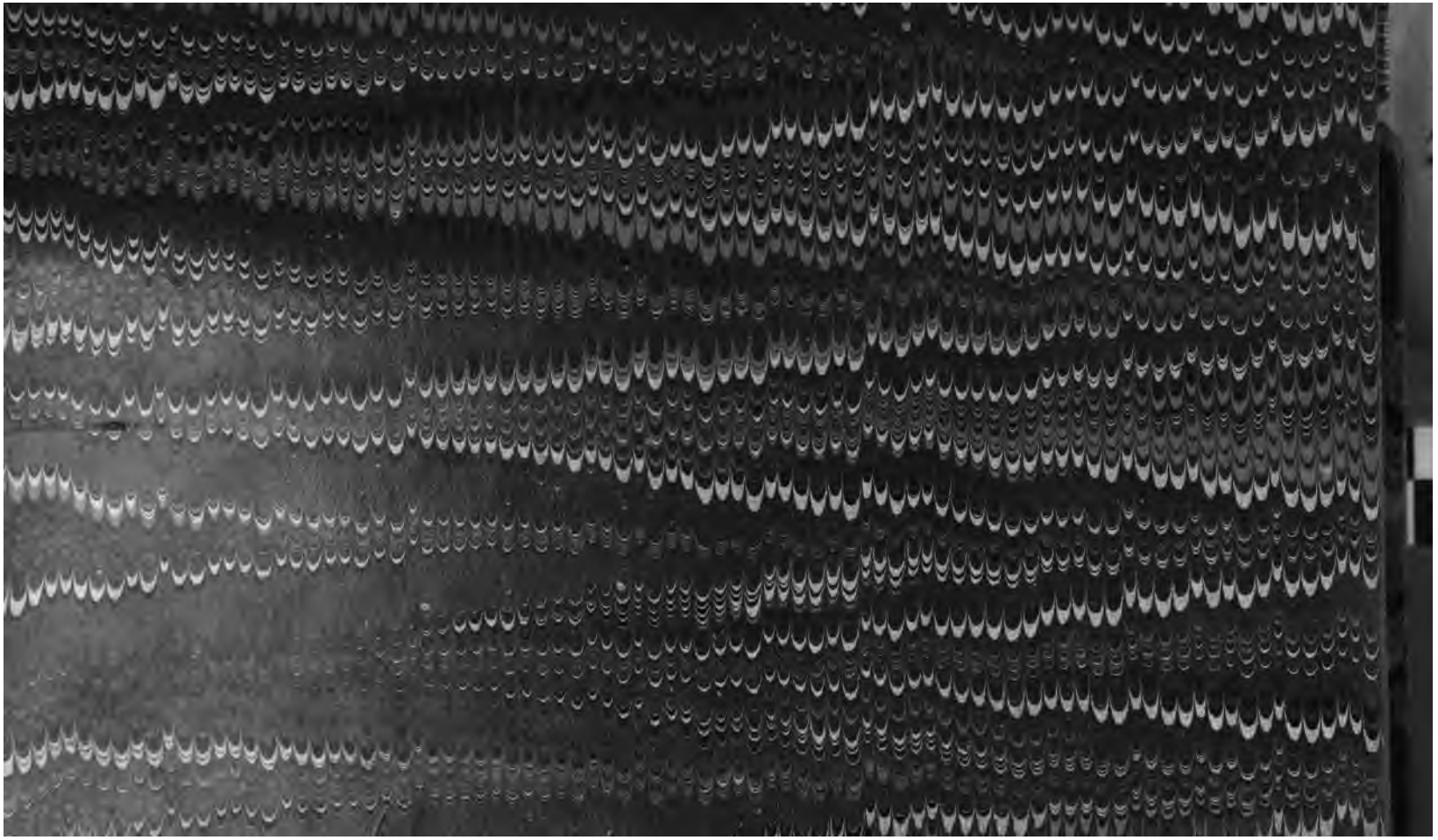

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51ST CONGRESS, 1st Session. | SENATE. | REPORT 928, Part 3.

REPORT

OF THE

SPECIAL COMMITTEE

OF THE

UNITED STATES SENATE

ON THE

IRRIGATION AND RECLAMATION OF ARID LANDS.

VOL. II.—THE GREAT BASIN REGION AND CALIFORNIA.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

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VOL. II.

THE GREAT BASIN REGION AND CALIFORNIA.

UTAH.
NEVADA.
CALIFORNIA.
ARIZONA.

IRRIGATION AND RECLAMATION OF ARID LANDS.

UTAH DIVISION.

SALT LAKE CITY, UTAH, *August* 19, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman), Plumb, Jones, and Reagan; also Director Powell.

STATEMENT OF A. L. THOMAS, GOVERNOR OF UTAH.

MR. CHAIRMAN AND GENTLEMEN: I have here some laws on the subject of irrigation in this Territory. The first is that contained in the compiled laws in regard to the organization of irrigation companies. Then there is a law in the session laws of 1878, amending that to some extent. Then we have a law passed in 1880, providing for the recording of vested rights and the use of water. To-morrow I shall file a statement respecting this latter law. And I would say that the courts have adjudged some of them unconstitutional.

The laws referred to are as follows:

WATER RIGHTS.

SEC. 422. Whenever, by priority of possession, rights to the use of water for mining, agricultural, manufacturing, or other purposes, have vested and accrued, and the same are recognized and acknowledged by the local customs, laws, and the decisions of courts, the possessors and owners of such vested rights shall be maintained and protected in the same; and the right of way for the construction of ditches and canals for the purposes herein specified is acknowledged and confirmed; but whenever any person, in the construction of any ditch or canal, injures or damages the possession of any settler on the public domain, the party committing such injury or damage shall be liable to the party injured for such injury or damage.

SEC. 423. All patents granted, or pre-emption or homesteads allowed, shall be subject to any vested and accrued water right, or rights to ditches and reservoirs used in connection with such water rights, as may have been acquired under or recognized by the preceding section.

SEC. 424. The right to the use of water for the reclamation of desert lands, in accordance with the provisions of an act approved March third, eighteen hundred and seventy-seven, shall depend upon bona fide prior appropriation; and such right shall not exceed the amount of water actually appropriated, and necessarily used for the purpose of irrigation and reclamation; and all surplus water over and above such actual appropriation and use, together with the water of lakes, rivers, and other sources of water supply upon the public lands and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes, subject to existing rights.

SEC. 425. All navigable rivers, within the Territory occupied by the public lands, shall remain and be deemed public highways; and in all cases where the opposite banks of any streams not *navigable* belong to different persons, the stream and the bed thereof *shall become common to* both.

SEC. 2775. s 1. The selectmen of the several counties of this Territory are hereby created ex-officio water commissioners for their respective counties, whose powers and duties shall be to make, or cause to be made and recorded, such observations, from time to time, as they may deem necessary, of the quantity and flow of water in the natural sources of supply, and to determine, as near as may be, the average flow thereof at any season of the year, and to receive, hear, and determine all claims to the use of water, and on the receipt of satisfactory proof of any right to the use of water having vested, to issue to the person owning such right a certificate therefor for recording, and to generally oversee, in person, or by agents appointed by them, the distribution of water within their respective counties, from natural sources of supply, to all the corporations or persons having joint rights in and to any natural source of supply, and to fairly distribute, according to the nature and extent of recorded rights, and according to law, to each of said corporations or persons their several portions of such water; and in case of dispute between any of such persons or corporations as to the nature or extent of their rights to the use of water or right of way, or damages therefor, of any one or more of such persons or corporations, to hear and decide upon all such disputed rights, and to file a copy of their findings and decisions as to such rights with the county recorder, and to distribute the water according to such findings or decision, unless otherwise ordered by a court of competent jurisdiction.

SEC. 2776. s 2. In cases where persons, or corporations, use water in different counties from the same natural source of supply, the water commissioners of each of said counties shall unite in appointing, either from among their number or otherwise, as they may determine, a board of reference of not less than three competent persons, to hear and decide all disputes in regard to water rights in and to such natural source of supply, and they shall file a copy of their decision with the county recorders of each of said counties; said water commissioners and members of the board of reference shall each, respectively, have power to administer oaths, and if any person who may be duly sworn in any matter in relation to the nature, extent, or exercise of any right or duty under any of the provisions of this act, shall falsely swear, such person shall be deemed guilty of perjury.

SEC. 2777. s 3. The certificate of the water commissioners shall state generally the nature and extent of the right to use water of the person, or corporation, to whom it is issued, and must be filed with the county recorder for recording.

SEC. 2778. s 4. It shall be the duty of the county recorder of each county, upon any certificate of water commissioners being filed in his office, as prescribed by this act, and upon any findings or decisions of any commissioners, or board of reference, as to the extent of any such rights, and upon payment of the fees allowed by law for such service, to record, in a book, or books, to be kept by him for such purposes, all such certificates, findings, and decisions, which said record shall be deemed to impart notice to all persons whomsoever of the contents thereof, and shall be prima facie evidence of the existence and verity of the facts therein recited.

SEC. 2779. s 5. No person, or corporation, shall maintain any suit, at law or in equity, for the determination of the existence or extent of any right, or rights, to the use of water in this Territory, until after the decision of the proper county commissioners, or of the proper board of reference, as the case may be, unless said commissioners, or board, shall fail and neglect to hear and decide such person's claim of right to use of water for more than three months after such person may have presented, in writing, his claim, or claims, and evidence in support thereof, for adjudication: *Provided*, This section shall not be construed to affect or impair the authority or jurisdiction of any court in the issuance of a temporary injunction or restraining order in such cases, or to abridge the right of any person aggrieved by any such decision to maintain any lawful suit, or appeal, after such decision may have been made.

SEC. 2780. s 6. A right to the use of water for any useful purposes, such as for domestic purposes, irrigating lands, propelling machinery, washing and sluicing ores, and other like purposes, is hereby recognized and acknowledged to have vested and accrued, as a primary right, to the extent of, and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever any person or persons shall have taken, diverted and used any of the unappropriated water of any natural stream, water-course, lake, or spring, or other natural source of supply.

2. Whenever any person or persons shall have had the open, peaceable, uninterrupted, and continuous use of water for a period of seven years.

SEC. 2781. s 7. A secondary right to the use of water for any of said purposes is hereby recognized and acknowledged to have vested and accrued (subject to the perfect and complete use of all preliminary rights) to the extent of and reasonable necessity for such use thereof, under any of the following circumstances:

1. Whenever the whole of the waters of any natural stream, water-course, lake, *spring, or other natural source* of supply has been taken, diverted, and used by prior

appropriators for a part, or parts, of each year only; and other persons have subsequently appropriated any part, or the whole, of such water during any other part of such year, such person shall be deemed to have acquired a secondary right.

2. Whenever, at the time of an unusual increase of water exceeding seven years average flow of such water, at the same season of each year, all the water of such average flow then being used by prior appropriators, and other persons appropriate and use such increase of water, such persons shall be deemed to have acquired a secondary right.

SEC. 2782. s 8. A right to the use of water may be measured by fractional parts of the whole source of supply, or by such fractional parts, with a limitation as to periods of time when used, or intended to be used; or it may be measured by cubic inches with a limitation as to periods of time when used or intended to be used; or it may be measured by cubic inches with a limitation specifying the depth, width and declination of the water at point of measurement, and, if necessary, with a further limitation as to periods of time when used, or intended to be used, and such right may be appurtenant to the land upon which such water is used, or it may be personal property, at the option of the rightful owner of such right, and a change of the place of use of water shall in no manner affect the validity of any person's right to use water, but no person shall change the place of use of water, to the damage of his co-owners in such right, without just compensation.

SEC. 2783. s 9. A continuous neglect to keep in repair any means of diverting or conveying water, or a continuous failure to use any right to water, for a period of seven years at any time after the passage of this act, shall be held to be abandonment and forfeiture of such right, and whenever hereafter a conveyance of any parcel of land is executed, and a right to the use of water has been continuously exercised from the time of its first appropriation, in irrigating such land, such right shall pass to the grantee of such conveyance; and in cases where such right has been exercised in irrigating different parcels of land at different times, such right shall pass to the grantee of any parcel of land on which such right was exercised next preceding the time of the execution of any conveyance thereof; subject, however, in all cases, to payment by the grantee of any such conveyance, of all amounts unpaid on any assessment then due upon any such right: *Provided*, That in any of the cases mentioned in this section, any such right to the use of water, or any part thereof, may be reserved by the grantor of any such conveyance, by making such reservation in express terms inserted in such conveyance.

SEC. 2784. s 10. All rights to the use of water, and means of diverting water, shall be exempt from taxation, except for the purpose of regulating the use of the exercise of such right in all cases where the land or other property upon which the pertaining to such rights is assessable for taxation, but in making the assessment the assessor shall estimate the increased value of such land or other property, caused by the use of such water.

SEC. 2785. s 11. It shall be the duty of all persons using water from any natural source of supply to provide suitable ditches for conveying surplus water again into the natural channel, or other places of use, to the satisfaction or approval of the water commissioners; and if, through neglect so to provide such ditches, water is allowed to form pools or marshes, or otherwise run to waste, and if any person shall turn or use any water in a manner that damages the property of another, except when such turning or using in the prudent, careful exercise of such person's lawful right to so turn or use, such person or persons so offending shall be liable for damages to any aggrieved person entitled to the use of water from the same source of supply, and the water commissioners may, on application, or of their own motion, cause the water supply to be diverted from such offending party until such waste ditches are provided.

SEC. 2786. s 12. Whenever the terms mentioned in this section are employed in this act, they are employed in the sense hereinafter affixed to them, except when a different sense plainly appears;

1. The term "person," when applicable, includes "firm," "partnership," "joint-stock company," "association" and "corporation."

2. Words in the singular number may include the plural, and words in the masculine may include the feminine.

3. The term "continuous use" includes use for that part of each year necessary for the purpose used for.

SEC. 2787. s 14. Whenever the waters of any natural source of supply are not sufficient for the service of all those having primary rights to the use of the same, such water shall be distributed to each owner of such right in proportion to its extent, but those using the water for domestic purposes shall have the preference over those claiming for any other purpose, and those using the water for irrigating lands shall have preference over those using the same for any other purpose, except domestic purposes: *Provided*, such preference shall not be exercised to the injury of any vested right, without just compensation for such injury.

SEC. 2788. s 15. All persons shall have the right of way across and upon public,

private, and corporate lands, or other right of way, for the construction and repair of all necessary reservoirs, dams, water-gates, canals, ditches, or flumes, other means of securing and conveying water for any necessary public use, or for drainage, upon payment of just compensation therefor, but such right of way shall in all cases be exercised in a manner not to unnecessarily impair the practical use of any other right of way, highway, or public or private road, nor to unnecessarily injure any public or private property.

SEC. 2789. s 16. Whenever a majority of individuals owning several rights to the use of water, and a joint interest in the means of diverting or conveying such water, or who may desire to divert and use any unappropriated water, desire to organize themselves into an association for the purposes of regulating the diversion and distribution of such water, they may organize into a corporation in the manner provided in "An Act providing for incorporating associations for mining, manufacturing, commercial, and other industrial pursuits," approved February 18, 1870, and all amendments thereto, with power to levy and collect all necessary assessments, and the distribution of water to each stockholder may be regarded as the payment of dividends, and such corporation shall have perpetual succession, unless dissolved by three years' nonuse of its rights, or by a two-thirds majority vote of its members, at a meeting called for that purpose; in all cases of dissolution, the property held by the corporation, shall revert to the members, in proportion to their rights therein, or they may organize into an irrigation district, under "An Act to incorporate Irrigation Companies," approved January 20, 1856, as they may elect.

AN ACT Compiling the Laws Relating to the Incorporation of Irrigation Companies.

SEC. 2403. s 1. *Be it enacted, etc.:* That upon the majority of the citizens of any county or part thereof, representing to the county court that more water is necessary, and that there are streams or part of streams unclaimed or unused, which, if brought out of their natural channels and thrown upon tracts of land under cultivation, or to be put under cultivation, can be of value to the interests of agriculture, the county court having jurisdiction may proceed to organize the county, or part thereof, into an irrigation district; and thereafter the landholders of such district shall be equally entitled to the use of the water in, or to be brought into such district, according to their acknowledged rights; *Provided*, Such landholders pay their proportion of the expense incurred in the construction and keeping in repair of the necessary canals, flumes, dams or ditches.

SEC. 2404. s 2. The citizens of an irrigation district, when so organized for the purposes provided in the preceding section, may, in mass meeting, proceed to the formation of a company, by electing, *viva voce*, not less than three nor more than thirteen trustees, a secretary and a treasurer. Notice of the time, place and object of said mass meeting shall be given by the clerk of the county court, at least ten days previous, by advertising three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district.

SEC. 2405. s 3. It shall be the duty of the trustees so elected to locate the proposed canal or ditch, determine the amount and quality of the land to be benefited thereby, to estimate the cost, including dams, flumes, locks, waste weirs and all the appurtenances belonging thereto, the amount per acre of the percentage on taxable property which will be necessary to construct the same.

SEC. 2406. s 4. It shall then be the duty of the trustees to make a report to the county court of the location and estimate provided for in section 3 of this act; also to call a meeting of the holders of the lands to be benefited by the proposed canal or ditch, at which a copy of said report shall be presented, and the said landholders shall vote "yes" or "no" upon the following questions:

1. Do you mutually agree to pay —— per acre, land tax, to construct the proposed canal or ditch?

2. Do you approve the action of the mass meeting in the election of officers?

Notice shall be given by the trustees at least ten days previous to the time appointed for such meeting, by advertising at least three times in some newspaper having general circulation in the county, and by posting up notices in three public places in the district. Said advertisement and notice shall state distinctly the time and place and object of such meeting, and be signed by a majority of the trustees and the secretary. The voting at said meeting shall be by ballot, and the chairman and secretary of said meeting shall be the judge and clerk of the election. A ballot-box shall be provided by the trustees, and each voter shall present his ballot to the judge of election, who shall deposit it in the box, and the clerk shall write the name of the voter in a poll-list or book, which shall also be provided by the trustees. No person shall be entitled to vote at said meeting or election unless he is a landholder in the district. Immediately after the close of the election the ballots shall be openly *counted by the judge* and clerk, assisted by two persons chosen by the voters present. *A certificate of the results* of the election, signed by the persons who counted the

votes, shall be forwarded at once to the clerk of the county court by the judge of said election.

SEC. 2407. s 5. If upon counting the votes it shall appear that two-thirds of the votes polled have been answered in the affirmative, then the tax so agreed upon shall be a law in the said irrigation district; and the tax when collected shall be paid over to the treasurer of said company on his order; *Provided*, That not exceeding one-half of the tax so agreed upon shall be collected at one time, and the residue to be collected as the work progresses; *Provided further*, That if the first estimate prove insufficient for the construction of the canal or ditch with its appurtenances, then additional taxes may be assessed in the same manner as hereinbefore provided until the said canal or ditch is completed.

SEC. 2408. s 6. If less than two-thirds of the votes polled are answered in the affirmative, then all proceedings under this act shall be null and of no effect; *Provided*, That if there are objections to the officers so elected by the mass meetings, the electors may write other names on their tickets; the persons having the most votes to be declared elected, and it shall be the duty of the county clerk to notify such officers forthwith of their election.

SEC. 2409. s 7. Within twenty days after receiving such notice, the officers so elected shall file bonds in the office of the clerk of the county court, conditioned for the faithful performance of their several duties; the amount of such bonds to be declared by the county court having jurisdiction.

SEC. 2410. s 8. The term of office of the first trustees, secretary and treasurer, shall be till the next general election; and thereafter for two years, and until their successors are elected and file bonds.

SEC. 2411. s 9. All subsequent elections for determining the rate of tax shall be held annually on the first Monday in December, and for the election of company officers, biennially, on the same day, at such time and place within the district as shall be designated by the trustees, at which time the number of trustees may be changed by a two-thirds vote to not less than three nor more than thirteen. Notice of said election shall be given and the election conducted and certificates thereof returned, as provided in section 4 of this act, and the officers elected shall give bonds as provided in section 7 of this act. The rate of tax determined at said election by a majority vote shall be a law in said irrigation district, and shall constitute a permanent lien on the interest of the tax-payer in said canal or ditch and his right to the use of the water therein flowing from the day of assessment: *Provided*, That no tax created or payable by this act shall be or create a lien upon the land.

SEC. 2412. s 10. The trustees at their first meeting shall elect one of their number president, and it shall be their duty and they shall have power to fill any vacancy which may occur in the board by death, change of residence, or otherwise; and the persons chosen for this purpose shall hold office until the next annual election. The trustees shall also have power to meet at such times and places as they may deem expedient to make by-laws, rules, and regulations necessary to carry into effect the objects of the people; to appoint agents, subordinates, and officers, and employ such workmen as may be requisite; to appoint assessors and collectors, or make agreement with the county assessors to assess and collect the tax, and notify collectors when additional installments of the tax will be needed; to construct and complete said canals or ditches, with all necessary appurtenances thereto; to cause to be kept an account of all receipts and disbursements, and to complete said canals and ditches, and settle all accounts of the same. Said trustees shall make an annual report of their proceedings under this act to the county court on or before the first day of February, and shall file with the clerk of the county court a map of said irrigation district, showing the location and subdivision of land therein, and of the company's canals and ditches.

SEC. 2413. s 11. The trustees shall have power to sue and be sued, plead and be impleaded, to have and to hold all such real estate and personal property as may be necessary to construct the contemplated ditch or canal, including all appurtenances belonging thereto.

SEC. 2414. s 12. If any part of the lands to be benefited by the proposed ditch or canal are not legally claimed, then such lands may be appraised by the trustees and shall be held and the possession of them sold by the trustees, as opportunity may offer, and the estimated amount of the funds necessary to complete such canal or ditch shall be decreased by the estimated value of such lands, previous to the levy and assessment of any tax.

SEC. 2415. s 13. Where the streams to be taken out for irrigation purposes come from counties other than the one in which the district is situated, but where there are no existing claims to the water and where no individual or settlement will be injured thereby, then the power of said irrigation district is hereby extended to said other county, insomuch as said extension may be necessary for the construction of dams to turn the waters, and ditches or canals with all necessary appurtenances as may be necessary to convey the same to where it is to be used.

SEC. 2416. s 14. Where lakes or ponds in natural basins have outlets, or where such can be made by dams across hollows, such lakes or ponds may be used as reservoirs, to store water for lands lying on lower levels; and the people of any irrigation district may, under the provisions of this act, construct such artificial or use such natural basins for irrigation purposes: *Provided*, The waters of such lakes or ponds are in no case to be raised, by dams or otherwise, so as to interfere with or damage settlers upon the margin thereof.

SEC. 2417. s 15. Upon the construction or partial construction of any canal, ditch, or reservoir contemplated in this act, they shall become the property of the irrigation district; and thereafter all funds necessary for repairs upon said canal, ditch, or reservoir, and for keeping the same in order, or for altering or enlarging the same may be levied by a tax upon the lands benefited, the landholders in the district to vote upon the same in the manner heretofore provided for in this act. And in case of any sudden emergency, caused by inundation or otherwise, said trustees are hereby authorized and empowered to make such repairs, or take such measures as they may deem necessary to preserve the canals, or ditches, or other works of said company or district, and for payment of the expenses so increased the trustees are hereby authorized and empowered to levy a tax for the necessary amount upon all the lands of said district benefited by such canals or ditches, and said tax may be collected in the same manner and at the same time, if necessary, as provided for the collection of other taxes in said district.

SEC. 2418. s 16. All property or money belonging to any irrigation district, in the hands of the trustees to be expended by them under the provisions of this act, is hereby exempted from all city, county, and Territorial taxes.

SEC. 2419. s 17. After any canal or ditch shall have been laid out under this act, or under any special charter where other provision has not been made, the trustees or company may agree with the owners of land through which it will pass for the purchase of so much thereof as may be necessary for the making of the canal or ditch and the appurtenances thereto belonging.

SEC. 2420. s 18. In every case where the owner of the land so required shall absent himself from the country, or shall not, from any cause, be capable in law so to agree, or shall refuse to agree, or ask an exorbitant price, the value of such land and the damages to the owner thereof shall be ascertained in the following manner:

1. The owner of or claimant to such land and the trustees may each select a referee, and in case of disagreement the two may select a third, and these referees shall proceed to determine the value of the land under controversy, and assess the amount of damages, if any, which each owner of lands or improvements has sustained, or will sustain, in consequence of the canal or ditch.

2. The appraisal, with a description of the land so appraised, shall be acknowledged by the referees signing it, before the clerk of the county court of the county in which the lands are situated, and when so acknowledged it shall be filed in the said clerk's office within ten days after it shall have been made. In case the occupant or claimant shall refuse or neglect to select a referee as herein provided, the trustee may petition the district court of the district in which the land is situated for the appointment of three or more commissioners to condemn the land and fix and determine the damages; said commissioners to be appointed upon such notice to the complainant or occupant as said court shall direct. Said commissioners shall report to said court their award and determination for approval or disapproval. The motion for approval of said award shall be heard on such notice as the court shall direct.

SEC. 2421. s 19. The trustees, upon payment to the rightful claimant of the several sums assessed in the appraisal so made, or upon making a tender thereof when the same shall be refused, shall be entitled to enter upon the lands described in the appraisal, and have and hold the same for the use and benefit of such irrigation district forever.

SEC. 2422. s 20. If on any parcel of the lands so described there shall be no person then living authorized to receive payment for the damages assessed for such parcel, and such damages shall not have been lawfully demanded within ten days after the filing of such appraisal, the board of trustees may enter thereon without payment or tender of such damages, but subject to such payment whenever the same shall be thereafter lawfully required.

SEC. 2423. s 21. Any person, who, in violation of any right of any other person, or of said corporation, wilfully turns or uses the water, or any portion thereof, of said canal, ditch, or reservoir, except at a time or times when the use of such water has been duly distributed to such person, or wilfully uses any greater quantity of such water than has been duly distributed to him, or in any way changes the flow of water when lawfully distributed for irrigation or other useful purposes, except when duly authorized to make such change, or wilfully or maliciously breaks or injures any dam, canal, water-gate, ditch, or other means of diverting or conveying water for irrigation or other useful purpose, is guilty of a misdemeanor.

SEC. 2424. s 22. All companies or districts organized under the provisions of this act shall be liable for any damage which may occur by the breakage of any canal or ditch. When any land in an irrigation district is benefited or damaged by the company's canals or ditches, from soakage or other incidential cause, and the owner of said land and the company can not agree as to the amount of the benefit or damage, the matter in dispute, as well as the question of damage through breakage, may be referred and decided as provided in the preceding section of this act. No irrigation company organized under the laws of this Territory shall be entitled to divert the waters of any stream to the injury of any irrigation company or person holding a prior right to the use of said waters, and all cases of dispute arising from such unlawful diversion may also be referred and decided as provided in section 18 of this act.

SEC. 2425. s 23. Nothing in this act shall be so construed as to interfere with the right of the legislative assembly to repeal, alter, or amend the same at pleasure.

SEC. 2426. s 24. That persons who have constructed canals, ditches, or dams, and taken out water for irrigation purposes before the passage of this act to which this act is amendatory, are hereby authorized to organize under the provisions of said act, and to enjoy all the rights, powers, and privileges guaranteed therein: *Provided*, They shall proceed in the same manner as is provided for the organization of new companies.

SEC. 2427. s 25. Nothing in this act shall be so construed as to prevent any association of persons incorporating under the laws of this Territory relating to private corporations for general purposes.

STATEMENT OF ELIAS A. SMITH, OF SALT LAKE CITY.

The CHAIRMAN. I believe you are one of the commissioners of the Territory?

Mr. SMITH. I am one of the commissioners of this county.

The CHAIRMAN. You have been probate judge of the county?

Mr. SMITH. Yes; I was probate judge of this county for five years.

The CHAIRMAN. How long have you resided in Salt Lake?

Mr. SMITH. I was born here, and I am now thirty-one years old.

The CHAIRMAN. Are you familiar with the regulations made here governing the distribution of water among those who irrigate?

Mr. SMITH. Yes, some of them.

The CHAIRMAN. Will you state generally how you manage to distribute the water to the consumers?

Mr. SMITH. There are two or three systems. We have, first, the incorporators on the streams, controlling it themselves—they agree how it shall be manipulated; second, the county courts that matured and organized irrigating companies; and, third, private corporations, taking out charters the same as any other corporation would, as, for instance, a person or a company of men settle upon a stream and appropriate the water in it. In early times they had sufficient to irrigate what land they would break up. Those we will term the primary owners of the water. Afterward others would come who, finding a surplus of water in the stream, would appropriate still further water, and so on until all the water of that stream would be taken out. They dug their ditch, gave it some name, and took what water they could through their land. In establishing some streams there would be what is known as the first, second, and third right. The third right, when there is a scarcity of water, shuts off the entire stream, and the second and first rights take the entire stream. The owners of each of those ditches meet and appoint what is called a "water-divider" or "water-master," who has control of the ditch for that year, and whose duty it is to divide the water of the streams into ditches, as, for instance, if there were four streams drawing water, they would appoint a divider to turn the water of those streams into the ditches, and the water-master would take the water as it would get into the ditch and give it to the owners as their rights might appear. *I do not* think there is an irrigating ditch in the

Territory under the irrigation law; they have all taken out private charters.

The CHAIRMAN. Explain how that is operated.

Mr. SMITH. It is an incorporation where certificates of stock are issued under the general laws of the Territory. They elect their board of truestees and manage the affairs of the company. Those trustees appoint a water-master, who takes the number of shares each owner of it has and divides to each his proportion of the water that comes through a certain ditch from the stream. Those streams are mostly artificial streams, having been taken out from some large body of water. That system prevails more on the west side than on the east side, though there are some on the east.

The CHAIRMAN. Then the stockholders in the corporation have the land?

Mr. SMITH. Yes. But the water right can be transferred without transferring the land. It is a water right independently of the land.

The CHAIRMAN. Can a man sell his water right and keep his land?

Mr. SMITH. Yes; sell it the same as he could the stock in any corporation.

The CHAIRMAN. How does that work? What do they do with the water if they have not the land?

Mr. SMITH. I am one of those parties. I own stock in one of those corporations, yet I own no land. I rent my water by the year to owners of land.

The CHAIRMAN. Is there any law by which the price of water is regulated?

Mr. SMITH. No.

The CHAIRMAN. You can charge all you can get?

Mr. SMITH. All I can get, and the parties get it for as little as they can.

The CHAIRMAN. Then you take the water from one land owner and give it to another?

Mr. SMITH. Yes. But there is hardly a land owner but who has some water right.

Senator JONES. Does the corporation as a body rent this water?

Mr. SMITH. Each individual.

Senator JONES. The several members of the corporation dispose of the water to the farmers?

Mr. SMITH. The corporation has no water to dispose of. There is no corporate power to dispose of the water.

The CHAIRMAN. Does that lead to a monopoly?

Mr. SMITH. Not so far. There is one company, of which I am the secretary, that has issued 10,000 shares, and there are a little over four hundred owners of that stock. The largest owner holds 209 shares.

The CHAIRMAN. Do you regulate the amount of shares with reference to the amount of land to be irrigated?

Mr. SMITH. We count that one share of water will irrigate 1 acre of land. If a man have 80 acres of land he must provide himself with 80 shares of stock. The ditch is some 30 miles long. They take out of that what they call a weir ditch, and the owners of the land under that weir ditch appoint a water-master to divide the water out by the hour.

Senator REAGAN. Do you find complaint on the part of the land owners that there is a monopoly of the water?

Mr. SMITH. I have never heard it.

Senator REAGAN. Do you find complaint of excessive charges for *water?*

Mr. SMITH. I have never heard it.

The CHAIRMAN. There you have two of the systems; what is the third?

Mr. SMITH. The other is virtually the same, only the county court granted them a charter to take out and control a certain stream. They found that that stream did not work. I think in every instance in this county they have abandoned it.

The CHAIRMAN. They had that system in vogue in Carson when I went there. They had a county judge dealing out the water. There the county court assumed jurisdiction. But that has been abandoned here, you say?

Mr. SMITH. We found that it did not work. When there have been companies organized they have taken out what is called private incorporation charters under the laws of the Territory.

The CHAIRMAN. You have no corporation that sells water exclusively?

Mr. SMITH. I do not think there is a corporation in Utah Territory that rents water exclusively.

The CHAIRMAN. Then the only renters of water are the stockholders in these corporations who have a surplus, who have more stock than land, and they sell their surplus water to their neighbors?

Mr. SMITH. Yes, that is the only system in vogue in this Territory to-day. The legislature of Utah in 1880 passed a law leaving the entire water rights claim to be adjusted by the county commissioners, and afterward their judicial powers were annulled by decree of the court.

The CHAIRMAN. You recognize in the acquisition of the use of water priority of appropriation?

Mr. SMITH. Yes.

The CHAIRMAN. How do you limit the appropriation? If a man should take more water than he could use economically, would that be an appropriation in excess of what he ought to have?

Mr. SMITH. We have had but one suit of that kind, and that was this year—a suit where the party owning the primary right was using more water than was necessary to irrigate his land. The suit was brought to curtail him in the use of that water, and the court decided that he could only use enough to irrigate his land; that he should cause no waste of water. Now, we had a case where one person in what we call the primary class claimed that he had a better right than others in the same class, and the court decided that whenever there was a scarcity of water they should all share equally.

The CHAIRMAN. In this arrangement have you any supervision of the amount of water that should be used?

Mr. SMITH. None other than that the water master apportions to each person so many hours for the use of the water, and it is his business to see that he does not infringe upon the time of his neighbors, but if he should have more water than he needs in those hours, he could waste it if he should please to do so.

The CHAIRMAN. This is to say that if he did not see fit to ditch his soil he could allow the water to run to waste?

Mr. SMITH. Yes.

The CHAIRMAN. In some of these new constitutions the water is the property of the State.

Mr. SMITH. We have never considered it the property of the State, but of the individual.

The CHAIRMAN. But there is a pretty strong public opinion against wasting water, is there not?

Mr. SMITH. *Yes; a pretty* strong one. Judge Goodwin calls my at-

tention to the fact that we had a good deal of alkali land on which we turned water in abundance to wash the alkali out. In some places it would be called a waste; here we call it redeeming the land.

The CHAIRMAN. Do you not find it necessary to drain it off? If you turn water onto the land and allow it to soak away it will increase the alkali.

Mr. SMITH. Yes; but if we turn it on and permit it to stand for a little while it will raise the alkali and then we can wash it off.

The CHAIRMAN. But you must have drainage?

Mr. SMITH. Yes.

The CHAIRMAN. By putting on fresh-water after the alkali is taken off you can reclaim the land?

Mr. SMITH. Yes.

The CHAIRMAN. Where you have irrigated here and allowed the water to stand in low places has it not created alkali patches?

Mr. SMITH. Yes. If we turn water onto a place without providing a way of draining it we make alkali land.

The CHAIRMAN. Then drainage is as important where you have alkali to deal with as is the putting of water on to the land?

Mr. SMITH. Yes; in fact we have had to dig ditches to take water off that class of land. Of course, where we have the water measured and each person takes his own we have very little waste water.

The CHAIRMAN. Would irrigating properly and with proper drainage reclaim the land from alkali instead of putting more alkali on it?

Mr. SMITH. Yes; and then we can put on California clover.

The CHAIRMAN. Alfalfa is California clover?

Mr. SMITH. No; we have two classes. What we here term the California clover is larger and grows much longer.

Colonel Hollister asks me to explain the connection of the original water rights, through these certificates that in all instances relate to artificial streams.

Senator REAGAN. That is a fresh-water lake?

Mr. SMITH. Yes; it is 8 miles between the lake and the point of the mountains here. At the point of the mountains there is a dam placed in there, ostensibly for the purpose of storing water in Utah Lake. From the Jordan River there are five large canals taken out, two at the dam and three below it. But they are all taken from the waters of the Jordan. There are three on one side and two on the other. One goes to Salt Lake City, one to farms on the east side, and three to the others. Salt Lake County put in the dam out of the funds of the county.

The CHAIRMAN. To store more water?

Mr. SMITH. To store more water, and with a view to bringing under cultivation a greater area, and in each of these canals on the west side expended means toward helping the incorporators take out water. The companies were incorporated the same as most any other company, except that the capital stock was to be paid off in the excavation of the canal.

The CHAIRMAN. That is to say, they worked it out?

Mr. SMITH. Yes. There had to be some cash assessments, for supplies; but the most of it was done through the work of individuals. The greatest number of shares that any one person was permitted to have in any one of these canals was 300.

The CHAIRMAN. That was giving the person holding that number of shares 300 acres of land?

Mr. SMITH. The water for 300 acres of land. My father was the *largest owner, and his stock will be divided so soon as his estate is divided. He held 209* shares.

The CHAIRMAN. Then, as I understand you, Salt Lake County organized corporations?

Mr. SMITH. They organized no corporations; they aided those corporations.

The CHAIRMAN. The corporations organized to construct these canals were composed of persons who were allowed to put in their labor and obtain stock, and the county furnished a little money.

Mr. SMITH. No; the county put in the dam and built, I think, the first 3 miles of the canal. That was the hardest canal to build. It was on a side hill all the way around there for 8 or 10 miles.

The CHAIRMAN. And the county made no charge against the corporation for that?

Mr. SMITH. We did make a charge against the canal company. But it was afterward settled. When I went in as probate judge I found that against the canal company on the books of the county, and we made an arbitration in which we received a small amount and canceled the obligation. In another case we had the canal take stock in the corporation, and when I went in there we still had that stock in the county treasury. But we improved the road and allowed those who worked on the road to receive stock to get rid of it.

The CHAIRMAN. That was a combination of individuals by putting in their own work to construct a ditch, and no money was necessary except for obtaining supplies and tools?

Mr. SMITH. Yes, and powder for blasting purposes. On the west side of this river there are 20,000 acres that receive water from these ditches. This lake is exclusive to Salt Lake City.

The CHAIRMAN. Those corporations of which you spoke are simply corporations of individuals to bring in water to put on the land?

Mr. SMITH. Yes.

The CHAIRMAN. Did they put in the money?

Mr. SMITH. Mostly labor. Of course, where a man did not wish to work it out he paid some one to do it for him.

The CHAIRMAN. It does not require much capital to do this?

Mr. SMITH. No; if it did the canals would not have been built.

The CHAIRMAN. Then you have built most of them by men putting in their labor?

Mr. SMITH. Yes. I do not know of a canal that was constructed in any other way. I think this one on the west side of the river has cost in the neighborhood of $200,000 or $250,000.

The CHAIRMAN. And that was put in by labor?

Mr. SMITH. Yes.

Senator JONES. That canal will irrigate how much land?

Mr. SMITH. From 5,000 to 10,000 acres.

Director POWELL. Be good enough to explain that a little further. They went in and labored on these canals as men go on our roads and labor, and their wages were computed at so much, so that the cost of those canals was increased in that way?

Mr. SMITH. In going on the dams the men were allowed so much per day, while if they had actual cash, the price would have been reduced.

The CHAIRMAN. They allowed the men all the same wages?

Mr. SMITH. Yes.

The CHAIRMAN. What were the wages?

Mr. SMITH. Four dollars a day, man and team. There are 10,000 shares in the company, which to-day can be bought at $12 per share, and that would be $120,000 for the canal.

Senator PLUMB. *Would that* represent about the actual cash cost?

year. You can extend that all over the Territory. In the southern part they can raise more on account of cutting one more crop.

The CHAIRMAN. There would be then probably 6 or 8 tons per year?

Mr. SMITH. They can raise one more crop than we can.

The CHAIRMAN. Do you raise a good quality of potatoes?

Mr. SMITH. Good quality; and the land will produce in some places one quality and in others another quality.

The CHAIRMAN. What would be the production on this rich land?

Mr. SMITH. Five hundred bushels to the acre.

The CHAIRMAN. And of other vegetables in like proportion?

Mr. SMITH. Yes. It is very productive land.

The CHAIRMAN. How does fruit grow here?

Mr. SMITH. It grows very well. But the last few years we have been troubled with a moth, which has made our fruit crop a failure. It has been to a certain extent abandoned—the apple, for instance. What we do raise is very choice fruit. Peaches do not thrive, except in certain localities.

Senator REAGAN. What is the nature of this moth?

Mr. SMITH. It is in the shape of a worm that enters the apple.

Senator JONES. What is the irrigating season here?

Mr. SMITH. In May, and it runs to October. Alfalfa is the last we irrigate.

Senator JONES. What do they do with the water in the winter?

Mr. SMITH. In Utah Lake we put in the boards at the dam and hold it back, and of the mountain streams coming west we retain what goes into the lake. When the height of the water in the lake is not beyond the point we have agreed upon, we can hold it.

Senator REAGAN. But some seasons it gets above that?

Mr. SMITH. Yes.

The CHAIRMAN. If you could save it at that time do you think it would help you enough?

Mr. SMITH. Unquestionably so.

Senator JONES. You have not found it economical to store water from other sources of supply?

Mr. SMITH. We have not. But from now on we will. We in the city will have to find a place to store water for use in the winter season. In the winter and spring seasons the streams become torrents.

The CHAIRMAN. Are you familiar with the summits of the mountains, to be able to say whether there are flats up on them?

Mr. SMITH. Yes; there are cañons that have flats.

The CHAIRMAN. With a narrow gorge and a valley between them?

Mr. SMITH. Yes. But there are others who are better acquainted with that matter than I am.

Senator PLUMB. What arrangement is being made for a canal from Bear River?

Mr. SMITH. There is what we call the Boutwell system that is started there.

Senator PLUMB. Is that a corporation?

Mr. SMITH. It is a corporation, and for the same purpose as ours of letting water to land-owners. It is separate from the land, however.

Senator PLUMB. They have an incorporation to get their water right and get their contract?

Mr. SMITH. They have their contract, but there will be a question as to the water-right.

Senator PLUMB. Between them and the prior appropriators?

Mr. SMITH. Yes.

obtains this water from the mountain stream it differs. South here, at Draper, it would average about the same as on the west side. On the east side, 18 miles south of the city, is worth $40 or $50 an acre. Then they have the mountain stream where the land would come higher, from $50 to $75; and the further up the land would average $100 an acre; that is, where they have the mountain streams.

Senator JONES. Why is that?

Mr. SMITH. They have always considered the mountain streams a better source of supply. There is a débris that comes down with the mountain streams which increases the fertility of the land. Then, when you get right south of the city, up to about two years ago the land was rated at $300 an acre. That was farming land. In the last year or two it has increased in value. But that is due to the fact that it is looked after for residences. Within a radius of six miles from the city you can hardly get farming land for less than $300 an acre.

Senator REAGAN. What is the height and length of the dam?

Mr. SMITH. The length of the dam is about 120 feet, and I think it was put in something like 4 feet high. They have boards to put in to raise it 9 feet higher.

Senator REAGAN. Does that overflow the plains?

Mr. SMITH. It does not; but it will overflow the border of Utah Lake. It would not overflow below the lake and the dam, but it would overflow the lake and the land adjacent to it. We finally entered into an arbitration and agreed to what height we could raise the water.

The CHAIRMAN. Would it fill if you raised the dam higher?

Mr. SMITH. It could fill. Utah Lake has been known to be some 6 or 7 feet higher than it is to-day.

The CHAIRMAN. Could you have it higher and cover more land?

Mr. SMITH. Yes; I think we could.

The CHAIRMAN. There is a good deal of water runs to waste?

Mr. SMITH. There has not been for the last two or three years; but it has been so that it did run to waste.

The CHAIRMAN. Could the water be saved over or would it evaporate?

Mr. SMITH. We could save it over. There is some land unsurveyed adjacent to it, but it is occupied by what we call squatters, and their rights we have to respect. It it were not for them we could raise the water in Utah Lake, and it could be used to an advantage below. There is not sufficient water in all these ditches to irrigate all the land under them.

Senator REAGAN. Would it be too expensive to levee it?

Mr. SMITH. Yes. On the west side it is a natural reservoir, and on the east it is of a sloping character, and can not be leveed.

The CHAIRMAN. Are you familiar with the crops they produce, so as to be able to say what character of crops they raise there? How much of wheat do they produce?

Mr. SMITH. On $300. an acre land, within 6 miles of the city, from 40 to 50 bushels to the acre. That is on the east side.

The CHAIRMAN. And of oats?

Mr. SMITH. In the neighborhood of 90 bushels to the acre.

The CHAIRMAN. And barley?

Mr. SMITH. I could not say as to barley.

The CHAIRMAN. Do you raise alfalfa?

Mr. SMITH. Yes.

The CHAIRMAN. What kind of crops?

Mr. SMITH. They will raise in the neighborhood of 4 or 5 tons per

Senator PLUMB. In Weber they pay the same price as here?

Mr. SMITH. Yes. They are all competing for the trade.

Senator PLUMB. Is the land the same price up there as it is here?

Mr. SMITH. No. I was the chairman of the board of equalization of taxes, and passing through the Territory to assess the land in Cache Valley I saw the best farming land, and it averages about $45 an acre, and will produce as much per acre as land in this county.

Senator PLUMB. What is the best character of land? What makes the distinction between the best, the next best, and the poorest?

Mr. SMITH. Productiveness and fertility of the soil.

Senator PLUMB. Is it bench land or bottom land, or a combination of both?

Mr. SMITH. Combination of both. The mountain streams run down and bring a good deal of débris. That débris goes on the soil and fertilizes it. It makes the land very rich and productive.

Senator PLUMB. Is distance from the main ditch any element in the cost of land?

Mr. SMITH. No; whether it is at the head or tail of the ditch the land is the same price.

Senator PLUMB. Do all these farmers who own and occupy this land understand the process of irrigating—do they all do it alike?

Mr. SMITH. Yes; I think they all use the same system.

Senator PLUMB. Do they all understand it alike?

Mr. SMITH. Yes; of course, you will find land in this Territory where the fertility is different from the land adjacent to it; one is good and the other has mineral in it.

Senator PLUMB. All these farmers understand how to make the best use of the water?

Mr. SMITH. Yes. Most of the farmers in this county are old residents, and know from experience how to irrigate the land.

Senator PLUMB. How much water is deemed necessary to irrigate the land?

Mr. SMITH. There is no measurement. They run it off into an irrigating stream for so many hours, the amount a man can use to the best advantage.

Senator PLUMB. What is the largest farm in the Territory that you know of, that is to say, land that is actually farmed?

Mr. SMITH. By any one person?

Senator PLUMB. Yes.

Mr. SMITH. I will state that the largest farm that I found that was all irrigated was one of 210 acres. That was in the Cache Valley, in a compact body, owned and farmed by one man. There are some parties that of course own a considerable quantity of land that they do not irrigate.

Senator PLUMB. And they are holding it for speculation?

Mr. SMITH. Holding it for speculation. For instance, under the new canal that is started, there is one company that bought from the railroad something like 10,000 to 15,000 acres.

Senator PLUMB. Take the actual farmer in the Territory, a man who occupies the land he expects to make use of himself, for pasturage and all?

Mr. SMITH. I think you could put it at a thousand acres.

Senator PLUMB. What is the average?

Mr. SMITH. I do not think it would be over 25 to 40 acres. I do not think in this county it will average 15.

Senator PLUMB. These holdings must have been diminished in quantity lately?

Mr. SMITH. No. In the first place, in settling this Territory they surveyed first into 5-acre tracts, and each person drew lots for his land, and each got a lot. Then south of that were 10-acre lots; and to-day you will find some of the original owners holding that land, 10 and 5 acre tracts.

Senator PLUMB. And who never owned more?

Mr. SMITH. Yes.

Senator PLUMB. And they are making a living on it?

Mr. SMITH. Yes. Most of our farmers own stock in the way of sheep, and for pasturage they run in the mountains. Of course, our mountains are full of grass and will sustain the stock.

Senator PLUMB. When your people came to take land under the laws of the United States they took 160 acres?

Mr. SMITH. Yes.

Senator PLUMB. Have they held on to that?

Mr. SMITH. No. In this locality you will find one man would recognize the right of a neighbor and would deed to him for the expense of entering the land.

The CHAIRMAN. So that they entered for their neighbors?

Mr. SMITH. Yes. They had a mutual understanding. A man would enter upon a quarter section, and after he got his patent he would deed to his neighbor the actual amount of land on which he entered.

Senator PLUMB. Has there been any subdivision of the land?

Mr. SMITH. Yes, in most every instance.

Senator PLUMB. So that the tendency has been to diminish the area of holdings?

Mr. SMITH. Yes. In many instances they were poor men who could not hold the 160 acres.

The CHAIRMAN. Not able to irrigate it?

Mr. Smith. Yes.

The CHAIRMAN. How much should one man have?

Mr. SMITH. From these canals on the west side of the river he could own 40 acres; but on the east side he could not give good attention to 20. It is better, more productive, and needs a good deal of care; that is, to farm it well. A great many farm more; but I do not think they ever farm to advantage.

The CHAIRMAN. Do those who have more land usually do better?

Mr. SMITH. They do better, but they have to hire help. I am speaking of farmers, not men owning land and employing persons to till it.

Senator PLUMB. Does this land change hands?

Mr. SMITH. Very seldom. In the last year there has been more than for ten years previously.

Senator PLUMB. Does the annual production vary much?

Mr. SMITH. No; I think it was less this year than before. But you can count on so much.

Senator PLUMB. You say there was very little shifting in the agricultural districts?

Mr. SMITH. Very little.

Senator PLUMB. Does it diminish any?

Mr. SMITH. I think not.

Senator PLUMB. Generally increases?

Mr. SMITH. Generally increases; I do not think it diminishes.

Senator PLUMB. Take the land in the Cache Valley which yields so much; why is it not worth as much as that in Salt Lake Valley?

Mr. SMITH. I have told my friends that Cache Valley was the place for men to *go and settle.*

Senator PLUMB. If you get land in this valley does it increase in value because of its proximity to a large city?

Mr. SMITH. I think so.

Senator PLUMB. But outside of this valley the value of the products should settle the value of the land.

Mr. SMITH. Not to my understanding. But still the people place a fictitious value on the land.

Senator PLUMB. What relation does that land in taxation bear to the actual value of the land?

Mr. SMITH. This year, on the 1st of January, it was about 45 per cent. of its actual value.

Senator PLUMB. When you say its actual value, do you mean this price of which you have spoken—$300 an acre?

Mr. SMITH. Some of that $300 an acre land changed hands at $800 and $1,000 an acre. That was assessed at $200 an acre.

Senator PLUMB. That was two-thirds of its actual value.

Mr. SMITH. That piece of land in this county we threw out, because it was a fluctuating price.

Senator PLUMB. I am speaking of that which is used for agricultural purposes, 6 miles out from the city.

Mr. SMITH. Forty-five per cent. of its actual value; it would average all the way from $150 down to $20 an acre.

Senator PLUMB. What is the rate of taxation?

Mr. SMITH. Three mills on the dollar for Territorial purposes. The tax for school purposes is 3 mills on the dollar.

Senator PLUMB. How are the districts created?

Mr. SMITH. The county court divided the county into school districts, and upon the second Monday in June the resident tax-payers meet to elect trustees, who are the trustees of the district. For school purposes each district can levy a tax not to exceed 2 per cent. in every year, and the trustees themselves can levy a tax not to exceed one-quarter of 1 per cent. without a vote of the tax-payers.

Senator PLUMB. Then the people themselves can levy more?

Mr. SMITH. Two per cent. But it requires a two-thirds vote to levy that tax.

Senator PLUMB. How is the Territorial tax distributed?

Mr. SMITH. It is a 3-mills tax, and distributed to the various districts in the Territory not confined to any one county. It is a Territorial tax. In the county of San Pete they draw from the Territorial treasury for school purposes $12,200 more than they pay into the treasury, on account of the land being low and the per capita of the children being high.

Senator PLUMB. What is the school age?

Mr. SMITH. Between eight and sixteen. The school tax for last year was $2 per capita.

Senator PLUMB. To what extent do you think the area of this Territory could be increased?

SMITH. It could be increased, I think, if we had the water, to a third more of agricultural land than we are to-day tilling.

Senator PLUMB. Do you think water is within reach under this process of storing which you have suggested?

Mr. SMITH. I think we could add a third. There is plenty of water in the flood seasons of the year to irrigate all the land necessary. This, of course, does not count such large tracts as this canal contemplates, the Bear River Canal. It has been considered heretofore as being in *such a position as not* possible of being irrigated, on account of the *expense.*

The CHAIRMAN. Is there much of that water that runs to waste?

Mr. SMITH. Yes, in the Bear River.

The CHAIRMAN. Can they not increase the water a great deal by making a reservoir of Bear Lake?

Mr. SMITH. I question the advisability of storing water in Bear Lake. I own a ranch on Bear Lake, and there is no large stream of water that flows into the lake. The lake is supplied principally from the springs. They are contemplating raising the lake some 5 feet, but I do not think there is sufficient water goes into it to raise it that high. I think evaporation would take it off.

Senator JONES. There is a continual outflow from the lake?

Mr. SMITH. Yes.

Senator JONES. In certain seasons there would be no objection to saving that outflow?

Mr. SMITH. I think evaporation would keep it down.

Senator JONES. Would it increase the evaporation to decrease the outflow?

Mr. SMITH. I do not think it would, but it would be necessary to draw it off. It has not such a great flow as people imagine. I will say here that storing for twelve months the water that is now drained out would raise the lake a foot.

The CHAIRMAN. Whatever it did raise it would be so much gained?

Mr. SMITH. Yes.

Senator JONES. That which passes off in the flood season would be of some value?

Mr. SMITH. Yes.

Senator JONES. Does not Bear River get a considerable supply from Bear Lake?

Mr. SMITH. That I can not speak of.

Senator JONES. Is there not considerable land irrigated from Bear River?

Mr. SMITH. Yes; there are several mountain streams that furnish the water for Bear River. I think a small portion of it comes out of Bear Lake.

Senator PLUMB. What is the agricultural area of Utah at the present time?

Mr. SMITH. I do not know.

Senator PLUMB. You think the total area of cultivated land could be increased about a third?

Mr. SMITH. Yes.

The CHAIRMAN. Exclusive of the Bear River scheme?

Mr. SMITH. Yes. Of course we have land in the proximity of Bear River that could not be reclaimed. There is a good deal of waste land there.

Senator JONES. How much waste land is there under irrigation?

Mr. SMITH. I think the biggest tract that we had they had a canal coming to it. You can say that but a small percentage of the land of the Territory is what we call dry farming.

Senator JONES. In Idaho, in some localities under the foot-hills, they raise wheat without irrigation. Is there none of that kind of land here?

Mr. SMITH. There is, but it is a very small percentage. There is some in this vicinity; but I do not think it is 1 per cent. of the tilled land of the Territory.

Senator JONES. Do you think that is the rule?

Mr. SMITH. In some *places it is.* I think in Davis County they till

some. There they would go higher—4 or 5 per cent. But I do not think it would go above that.

Senator PLUMB. Is that successful generally—profitable farming?

Mr. SMITH. Some have thought so. But Davis County is the only place that I know of its being done with success. There they get from 15 to 20 bushels of wheat to the acre.

Senator PLUMB. Has there been any effort made to test food-plants raised in arid regions, that is, in Arabia, and so on?

Mr. SMITH. No.

Senator PLUMB. Only fruits?

Mr. SMITH. Last session the legislature made a provision for an agricultural college in Bear Valley.

Senator PLUMB. Nothing of that kind had been done before?

Mr. SMITH. No.

Senator PLUMB. Have the farmers of this country accumulated property? Do their material possessions increase from year to year?

Mr. SMITH. Yes. In this Territory, until late years, very few farmers owed for their farms. That is to say, they had no mortgages on them, and they accumulated year by year.

Senator JONES. You say until the last few years?

Mr. SMITH. Of course, some of them have made ventures in other directions.

Senator PLUMB. The mortgage crop is increasing?

Mr. SMITH. I am sorry to say it is increasing.

STATEMENT OF JESSE W. FOX, OF SALT LAKE CITY.

The CHAIRMAN. How long have you resided here?

Mr. FOX. On the 21st of September next, forty years.

The CHAIRMAN. Were you among the first settlers?

Mr. FOX. I came here in 1849. The pioneers were here two years before I came.

The CHAIRMAN. Had much progress been made in the way of cultivating the soil before you arrived?

Mr. FOX. Not a great deal. It was quite limited.

The CHAIRMAN. Were any of the settlers from countries where they had irrigated before coming here?

Mr. FOX. No, not any.

The CHAIRMAN. You came without experience in that direction?

Mr. FOX. I came without experience.

The CHAIRMAN. Did you meet with any difficulties in your first experiments with irrigation?

Mr. FOX. We at first did not know the amount of water that was necessary. The water was used liberally at first, until we became acquainted with the amount of water necessary to mature crops.

The CHAIRMAN. You knew when you first came here that this country would not produce crops without irrigation?

Mr. FOX. It was so announced by the pioneers on their return.

The CHAIRMAN. You came to the country with the full knowledge that you would have to put water on the land, and without ever having had any experience in that direction?

Mr. FOX. Yes. We were from Illinois, most of us, where we had plenty of rain.

The CHAIRMAN. Immediately after coming here you commenced to turn the water on to the land to irrigate it?

Mr. FOX. Yes; we turned the water from the mountain streams. This bench land to the east was the first cultivated.

The CHAIRMAN. Have the methods of using the water constantly improved since that time?

Mr. FOX. Yes.

The CHAIRMAN. You can irrigate a great deal more land now with the same amount of water than you could when you commenced?

Mr. FOX. We do.

The CHAIRMAN. You have been surveyor-general of the Territory?

Mr. FOX. Yes.

The CHAIRMAN. And you are familiar with the Territory?

Mr. FOX. Yes.

The CHAIRMAN. What amount of land in the Territory is now under cultivation?

Mr. FOX. I can not say the exact amount. We are extending our farming interests in different directions. There are new settlements forming in new localities.

The CHAIRMAN. You are constantly extending your farming; are new settlers coming in and occupying the land?

Mr. FOX. Yes.

The CHAIRMAN. How is that done?

Mr. FOX. Through entries, through the land office.

The CHAIRMAN. By taking out new streams of water?

Mr. FOX. By appropriating the water of what is called the basin, a deposit of Salt Lake, the great Salt Lake Basin. And, for instance, the water of the Weber River and the Provo and those larger streams we are taking out and applying to new localities through artificial canals.

The CHAIRMAN. The supply, then, is not exhausted?

Mr. FOX. This season it is more than exhausted.

The CHAIRMAN. With the exception of the dam at Utah Lake have any means been adopted of storing water in high latitudes?

Mr. FOX. We are now locating reservoirs, not very large ones, but temporary reservoirs.

The CHAIRMAN. Are you familiar with the mountain ranges and the topography of the country generally?

Mr. FOX. I am.

The CHAIRMAN. You are an engineer?

Mr. FOX. Yes.

The CHAIRMAN. Then you know pretty well about the snow-fall. You have kept a note of it?

Mr. FOX. I have kept no note of it

The CHAIRMAN. I mean from observation.

Mr. FOX. Yes.

The CHAIRMAN. Is there considerable opportunity for increasing the water supply by these reservoirs?

Mr. FOX. Yes.

The CHAIRMAN. Do you think it can be largely increased?

Mr. FOX. Very largely increased.

The CHAIRMAN. What proportion of the arable land in the Territory is now cultivated by means of irrigation? Of course, I ask for rough estimates; you are not expected to be accurate. Of course, occasionally there may be a dry spell?

Mr. FOX. I think we have exhausted the amount of water unless we resort to reservoirs.

The CHAIRMAN. By means of storage reservoirs how much can your agricultural area be *increased*?

Mr. FOX. Two hundred per cent., I think.

Senator JONES. Do you mean by that that it is the limit of the land or the limit of the water that may be obtained?

Mr. FOX. I think there is water that can be stored in artificial reservoirs to increase our irrigation at least 200 per cent.

Senator JONES. Is there a larger amount of land if you had water to irrigate than 200 per cent. increase would cover?

Mr. FOX. I think not.

Senator JONES. You think the capacity of the land and the water would be increased 200 per cent.?

Mr. FOX. Yes.

The CHAIRMAN. Through the Territory what is the average size of the irrigated farms?

Mr. FOX. Originally in locating the farming land throughout the country I had the oversight of it as Territorial surveyor-general, and every person who came had what they could cultivate judiciously. If he was a lone man or had a small family we gave him about 10 or 20 acres; if he was a man with four or five or six boys, we gave him more—from 40 to 60 acres. That was our standard in dealing out the country until the land came into the market.

The CHAIRMAN. After it came into the market those holdings were recognized and you distributed the land accordingly. But since the land has come into the market, do the holders have larger farms or do they enter and subdivide?

Mr. FOX. Sometimes they subdivide; but generally they retain their entry.

The CHAIRMAN. With these small farms have families been able to support themselves and get along very well?

Mr. FOX. Yes.

The CHAIRMAN. Have they grown more profitable in time?

Mr. FOX. Yes; if closely cultivated they are more profitable than a large farm.

The CHAIRMAN. That is, a man can make more money and support his family better on 40 acres well cultivated than he could were he to attempt to extend the area of his farm to 160 acres and cultivate it himself?

Mr. FOX. That has been our experience.

The CHAIRMAN. To cultivate a farm of 160 acres a man would have to employ help, would he not?

Mr. FOX. Yes; and the prices of products at the present time do not justify a man in hiring help.

The CHAIRMAN. What are farm wages here?

Mr. FOX. From $25 to $40 a month, including board.

The CHAIRMAN. What is the average crop of wheat in this Territory?

Mr. FOX. From 25 to 30 bushels to the acre.

The CHAIRMAN. What is the average crop of oats?

Mr. FOX. About 40 bushels.

The CHAIRMAN. Of barley?

Mr. FOX. Sixty bushels.

The CHAIRMAN. As I understand it, you raise larger crops in certain localities; but that is the average crop for the Territory?

Mr. FOX. Yes; 50 bushels of wheat have been raised; 80 bushels of barley, and about the same of oats.

The CHAIRMAN. What is the crop of potatoes where the land is well *cultivated?*

Mr. FOX. Three hundred bushels to the acre.

The CHAIRMAN. Do you raise as high as 500 or 600?

Mr. FOX. It has been reported that 600 bushels have been raised.

The CHAIRMAN. What has been the system of constructing your canals? Have they been constructed by individuals or by association in some form?

Mr. FOX. By association.

The CHAIRMAN. Do you form an association to build a canal?

Mr. FOX. We organize under the general irrigation act of the Territory. The organization is called a stock company, the same as a railroad company, or any other corporation that issues stock.

The CHAIRMAN. How is that stock paid for? How does a man get his stock from the corporation?

Mr. FOX. Either by a payment of cash or by furnishing labor to construct the ditch.

The CHAIRMAN. The money paid in is used in the construction of the canal?

Mr. FOX. Yes.

The CHAIRMAN. Is the stock issued to anybody except the land owners below the ditch?

Mr. FOX. The stock is an article to be purchased the same as railroad stock or any other stock.

The CHAIRMAN. To what does the stock entitle you?

Mr. FOX. To water from the ditch. The dividend is water.

The CHAIRMAN. And the dividend cannot be distributed except below the line of the ditch?

Mr. FOX. Yes.

The CHAIRMAN. Do you limit the amount of stock that each man may take?

Mr. FOX. No.

The CHAIRMAN. Suppose a man would have more stock than he would need for his land, thus getting more water than he has land, what would he do with the water?

Mr. FOX. Either rent it or sell it.

The CHAIRMAN. The company does not either rent or sell the water?

Mr. FOX. No, the individuals.

The CHAIRMAN. When you rent water here what rent do you generally receive?

Mr. FOX. About 10 per cent. of the cost.

Senator JONES. Is there anything to prohibit the holders of stock to authorize the company to act for them—having the company rent or sell the water without their control?

Mr. FOX. No.

Senator JONES. They can do that if they choose?

Mr. FOX. Yes.

The CHAIRMAN. Previous to the passage of your incorporation act, under which you have been operating recently, how did you do?

Mr. FOX. We would go to work and get the ditch out voluntarily.

The CHAIRMAN. And then divide the water among yourselves?

Mr. FOX. Yes.

The CHAIRMAN. You would have an understanding among yourselves, and each man would turn in and work?

Mr. FOX. Yes.

The CHAIRMAN. It was labor which the people put together in the beginning to do these things?

Mr. FOX. Not under *any law* of the Territory.

The CHAIRMAN. Not any law; but it was a voluntary arrangement among yourselves? As a rule settlers going into a region like this, unless they have capital, must associate their efforts to cultivate the land?

Mr. FOX. Yes. That was the method of getting out our water-ditches in early times.

The CHAIRMAN. Then you had the probate court to regulate matters between you, did you not?

Mr. FOX. Yes.

The CHAIRMAN. And now you have abandoned the regulation by the probate court?

Mr. FOX, Yes, I think so,

STATEMENT OF CHARLES HENRY WILCKEN, OF SALT LAKE CITY.

The CHAIRMAN. How long have you resided in Salt Lake City?

Mr. WILCKEN. Thirty years.

The CHAIRMAN. You are water-master here, I believe.

Mr. WILCKEN. Yes.

The CHAIRMAN. State the system you have of distributing water.

Mr. WILCKEN. We have a Territoriol ordinance that requires property-owners to file an application. In that they are required to state how many rods of land they are in possession of. When I get those applications, I divide the city into five districts. The ditches run that way, and it is convenient to divide into five districts. I then sum up the number of rights applied for, and I arrange it so that each man will get so many minutes to the rod, or so many hours each week. We get around generally once a week, except this year.

The CHAIRMAN. Are you familiar with the distribution of water outside the city—in the country?

Mr. WILCKEN. Some of it in the country. We have been short this whole summer in the county. We arrange it so as to have the water once a week, or once every ten days.

The CHAIRMAN. You have a water-master in the county?

Mr. WILCKEN. We have a water-master to divide the water into the large ditches. Then we have water-masters on every water ditch. They divide the time on the same principle that I do, except that they divide by the acre and not by the rod. But water comes around once in ten days, at any rate.

Senator JONES. In these districts here, after you have supplied the first, do you give to the others the full amount of water under the division?

Mr. WILCKEN. Yes.

Senator JONES. Suppose, after number one has been supplied, the water runs down; how much does the next one get?

Mr. WILCKEN. That much less water; but they get the quantity that the first district gets. We turn the water into the five districts at once.

Senator JONES. So that the falling off of the supply is all over the city?

Mr. WILCKEN. Yes. Of course, the person who lives at the head of the ditch has a little advantage of the one living at the end. There is evaporation and seepage going on, especially in the dry seasons.

Senator JONES. But practically it is uniform?

Mr. WILCKEN. Practically it is uniform.

The CHAIRMAN. That is what you aim at making it?

Mr. WILCKEN. Yes.

The CHAIRMAN. Are you familiar with the other portions of the Territory?

Mr. WILCKEN. Yes; I have traveled some in the Territory.

The CHAIRMAN. This system of having a water-master prevails generally throughout the Territory?

Mr. WILCKEN. Generally prevails. There is no contention; a person knows when his time comes for irrigating, and when he gets through with the water, the next one gets it.

The CHAIRMAN. Have you given any attention to the subject of storing water in the wet seasons, in the winter-time, with the view of meeting the requirements of a dry season like this.

Mr. WILCKEN. Yes. I believe it could be done for this county and city. I have studied a good deal on the subject of this water supply for Salt Lake, and I find that Utah Lake has the only storage capacity for irrigating purposes. It takes a great amount of water for irrigating purposes, and reservoirs could not be constructed in the cañons, because it takes too large an area to store the necessary water. But I have always felt that Utah Lake is the only place where we could get water for irrigating purposes. In the winter-time there are several rivers running into it, and we could store water there.

The CHAIRMAN. That absorbs a great portion of Utah County?

Mr. WILCKEN. Yes. Drains the water-shed from the east. There are several rivers, which, as a general rule, get up high in the spring and fill the lake. Then they have a dam at the lake to store water. There has been a little contention with the people in Utah County. The lake has been going down rapidly since 1884; people have crowded upon the land, and the moment we commenced to store water, thereby causing the lake to rise, there was a cry.

The CHAIRMAN. Within the last year there has been a reservation of any land needed for that purpose, and the Government will survey such land and set it apart; otherwise will there not be a disposition to crowd upon it and settle it up?

Mr. WILCKEN. Of course, some of the land has been entered; but whether they have perfected their titles or not I do not know. The water in Utah Lake for culinary purposes is not good; it is fishy. But for cultivating purposes it is better than the mountain streams.

Senator REAGAN. Where do you get your water for culinary purposes?

Mr. WILCKEN. Out of the mountain streams. We have a superintendent of water-works there, and for domestic purposes we would be obliged to have water out of those mountain streams. But of course some reservoirs might be built and exchanges made—bring the water for agricultural purposes from Utah Lake and give to the farmers in exchange.

Senator REAGAN. What kind of water is that which comes from Utah Lake?

Mr. WILCKEN. It is a little brackish, and tastes milky. It has a sediment in it, and does not chill the crop when you put it on. But the mountain streams chill the ground and set the crops back a year or two.

Senator JONES. Have you had any experience with flowing wells?

Mr. WILCKEN. I am driving some at present in Utah County. I have about sixty in operation there, throwing out about 6,000,000 gallons.

Senator JONES. How long have they been in use?

Mr. WILCKEN. I am driving wells that were started in Utah County a month ago.

Senator JONES. You have about sixty, and you began about a month ago?

Mr. WILCKEN. The city has eight or ten flowing wells.

Senator JONES. Has there been any benefit derived from the use of the water?

Mr. WILCKEN. In some localities there has been a great deal of benefit, where they get from 75 to 100 gallons per minute from an inch-and-a-half or two-inch pipe. Of course, several wells like that will irrigate a good deal of land. But in other localities we can only get from 4 to 10 gallons per minute. Where I am driving at the present time there seems to be a good water-shed. We are meeting with good success and getting good water.

Senator JONES. Are you using that water for irrigating purposes?

Mr. WILCKEN. Supply for the city—merely experiments to see what can be done.

Senator PLUMB. The water in the ditch flows into the city?

Mr. WILCKEN. It flows from there into the Jordan River, and then into our canal. In early years we took the first water that came up; but that is a failure. In driving down to the second and third streams you will find that that holds the better—seems to be more permanent and better water.

Senator PLUMB. What are the various depths of these wells?

Mr. WILCKEN. They vary. Where I am driving now it is 80 to 115 feet, with a 2-inch drill. I get some of them through that flow from 75 to 100 gallons per minute.

STATEMENT OF JAMES L. LITTLE, OF KANAB.

The CHAIRMAN. How far is Kanab south of Salt Lake?

Mr. LITTLE. Estimated at 330 miles, usually, by the wagon road and railroad.

The CHAIRMAN. How far from the Arizona line?

Mr. LITTLE. About 3 miles.

The CHAIRMAN. On what stream is your town situated?

Mr. LITTLE. It is called Kanab Creek.

The CHAIRMAN. How much of a stream is that?

Mr. LITTLE. I do not know what comparison I could give you. It would afford this season of the year about two heavy irrigating streams for a farmer, perhaps three.

The CHAIRMAN. How much land that is fit for irrigation is on the stream?

Mr. LITTLE. About 1,000 acres.

The CHAIRMAN. Are their other streams in that vicinity?

Mr. LITTLE. No; none to amount to anything for irrigation purposes.

The CHAIRMAN. Is there much irrigable land in the southern part of the Territory?

Mr. LITTLE. Yes; from the rim of the basin it is practically unlimited. When considered without connection with the supply of water the land is without limit.

The CHAIRMAN. Water, then, is the principal thing needed?

Mr. LITTLE. Yes.

The CHAIRMAN. Is the land good?

Mr. LITTLE. Yes.

The CHAIRMAN. What water supply have you?

Mr. LITTLE. Are you speaking of Kanab?

The CHAIRMAN. Yes.

Mr. LITTLE. Kanab Creek is the only stream in that country that amounts to anything for irrigation purposes until you get over to the head of the Sevier.

The CHAIRMAN. What streams are there in the southern part of the Territory? Over the rim, either in Utah or Colorado, how much country is there which could be irrigated?

Mr. LITTLE. It is a big country.

The CHAIRMAN. The water is limited?

Mr. LITTLE. Extremely limited.

The CHAIRMAN. And the land good?

Mr. LITTLE. A great deal of good land, yes; but there is a good deal of barren land there, some mineral land, etc. There is a good deal of land there that will not be irrigated for a generation or two at least.

The CHAIRMAN. The mountains are not high?

Mr. LITTLE. Pretty rugged—6,000 or 7,000 feet.

The CHAIRMAN. Is there any snow on the tops of the mountains?

Mr. LITTLE. Very little in the summer, but they're covered from autumn until May, in some places.

The CHAIRMAN. And there is enough water falls there so that you could store it?

Mr. LITTLE. The facilities for reservoirs are very abundant.

The CHAIRMAN. Would there be sufficient water supply?

Mr. LITTLE. A good deal of the water supply goes to waste.

Senator REAGAN. You have very heavy snows?

Mr. LITTLE. Yes; and there are also summer showers. There is considerable rain around the hills in July and August, when water goes to waste.

The CHAIRMAN. Explain that.

Mr. LITTLE. We can not utilize it at the time.

The CHAIRMAN. Does it come in the crop season?

Mr. LITTLE. Yes; but it comes in a torrent, a flood.

Senator REAGAN. And you have no dams to hold it?

Mr. LITTLE. No, but we are glad to shut up the heads of our ditches to hold it.

The CHAIRMAN. It is like a cloud-burst when it comes?

Mr. LITTLE. Yes.

The CHAIRMAN. And that is true of Arizona?

Mr. LITTLE. I understand so. All below the rim of the basin in Arizona the country is very similar in character.

The CHAIRMAN. But do you think it practical at the time those storms occur, if you had the reservoir, to retain the water?

Mr. LITTLE. Yes; more or less, if the reservoir were well constructed. But the soil of that country is loose. It is not the character of soil that is in the great Salt Lake Valley, and the water easily washes the soil away, thereby increasing our difficulties.

The CHAIRMAN. When we get to Arizona we will find the people familiar with the subject?

Mr. LITTLE. Yes; but the country changes.

The CHAIRMAN. When you get outside the rim of the water-shed where does the water discharge?

Mr. LITTLE. Into Salt Lake, into the valley. Salt Lake is the principal reservoir of Utah Lake.

The CHAIRMAN. How far south does the water flow toward Salt Lake, until you get to the rim?

Mr. LITTLE. To my knowledge it does not flow to Salt Lake.

The CHAIRMAN. How far is the water-shed?

Mr. LITTLE. Seventy-five miles below the county.

The CHAIRMAN. How much population, all together, have you in Utah on the south side where the water-shed goes into the Colorado River?

Mr. LITTLE. Say, perhaps, 15,000.

The CHAIRMAN. On what streams do they live principally?

Mr. LITTLE. On the Rio Virgin and the Santa Clara Rivers, and Kanab Creek. And there is a little water 12 miles east of the Kanab, which in the wet season of the year runs down into the country; but it is not fit for irrigation purposes. It has been stored a little.

The CHAIRMAN. Are you familiar with that country extending over to Muddy, and through there?

Mr. LITTLE. No.

The CHAIRMAN. You think by a system of reservoirs down there you could increase your population very much?

Mr. LITTLE. Yes; there is no doubt about that.

The CHAIRMAN. Have you been looking over the country with that view, having your attention called to the subject?

Mr. LITTLE. No; it is not in my line. But there is a report by the county surveyor which was printed in the papers.

The CHAIRMAN. What kinds of crops do you raise here?

Mr. LITTLE. All kinds that are raised in a temperate climate.

The CHAIRMAN. Do you raise any fruits?

Mr. LITTLE. Yes.

The CHAIRMAN. What kind of fruits?

Mr. LITTLE. Apples, peaches, plums.

The CHAIRMAN. And the small fruits?

Mr. LITTLE. Yes; gooseberries, grapes, etc.

The CHAIRMAN. There was an experiment tried down there some years ago in the direction of raising cotton. Did that succeed?

Mr. LITTLE. Not practically. I think it was a failure.

Director POWELL. Mr. Little could give you his experience in the development of irrigation in Kanab Creek and Sevier River. The Kanab would be a good illustration of the manner in which they have worked, and it would be instructive to the committee were it explained.

The CHAIRMAN. State what you have done on any one stream in Utah.

Mr. LITTLE. We first settled on Kanab Creek in 1870. We had at that time but a few settlers. At that time the water ran near the surface, with a wide sandy bottom, which made the evaporation so heavy in July that we could scarcely get the stream on to our gardens through the heat of the day.

Director POWELL. But go back of that and let us know about Upper Kanab.

Mr. LITTLE. I was not a settler there. I commenced right there in the sand.

The CHAIRMAN. Go on and give your experience.

Mr. LITTLE. We struggled until the water got to increasing to some extent. We reservoired a little in some places and helped ourselves. In the spring we had plenty of water to mature small grain, and perhaps we raised some corn, potatoes, etc. It ran along that way until the latter part of 1884. That was a stock country, and the people *turned their attention* to raising stock. They cultivated the soil only

to a limited extent, on account of the scanty supply of water. In the latter part of July, 1884, we had a tremendous flood. It tore what water ditches we had to pieces, and our dams disappeared, and the gulch went down in five or six hours in places 30 to 40 feet. Take the side of a house, and it will give you some idea of the flood. Of course it was muddy and piles of rocks and chunks of dirt were scattered along. The chunks of clay left on the surface of the ground as they came out of the creek into the valley are there to-day. We had to make a flume, and it was very hard on us as a settlement. Then we carried our ditch a mile further up the cañon toward this gulch. We had hardly got that done and some water on to our crops when there came another flood that tore that out. I think we made the third effort that season, if I remember aright, and then there came another flood and tore us up until we could do nothing. We were almost lost in the contemplation of our calamity for several days before we could settle upon the means of doing anything. Finally we had to build one or two dams—expensive ones.

The CHAIRMAN. How much water runs in an irrigating stream?

Mr. LITTLE. One hundred inches on the surface would make a good irrigating stream for a farmer.

The CHAIRMAN. How much land will a good irrigating stream irrigate in a season?

Mr. LITTLE. I think that the irrigating stream of to-day all runs in one ditch and will cover 800 or 1,000 acres.

Senator REAGAN. How do you utilize the water now that the gulch has been eroded so deep down?

Mr. LITTLE. That has been the difficulty. We struggled along and lived, got in a ditch when we could, perhaps not until the next season, and finally we got our city dam, which was built in the first place by that ridge by the rocks in the gulch. But our field dam has stood for three or four years. In flood time the water comes with such a character and such force on account of its density as to sweep everything before it.

The CHAIRMAN. Is not that a characteristic that must be met with in that country and in Arizona?

Mr. LITTLE. Yes. On the Rio Virgin our work is not yet a success. The last dam they put in on the Rio Virgin cost $10,000.

The CHAIRMAN. How would you construct reservoirs to avoid the destruction caused by these floods?

Mr. LITTLE. By pile-drivers, as we are now preparing to do in Kanab. I presume we will keep water pretty generally on our land now. But to-day the tax on our city lots is $16 a lot. Last year it was $30, and it has been $40 or $50 on our town lots. It has been expensive, without any result to amount to anything.

Senator PLUMB. The name of your place is Kanab. How far from the mouth of the stream are you?

Mr. LITTLE. It is right at the mouth of the gulch.

Senator PLUMB. Near the Colorado River?

Mr. LITTLE. It is about 63 miles from the Colorado?

Senator PLUMB. And Kanab Creek flows into the Colorado?

Mr. LITTLE. Yes.

Senator PLUMB. And your stream emerges from the hills?

Mr. LITTLE. From the divide.

Senator PLUMB. How much of a town have you there?

Mr. LITTLE. Ninety families.

Senator PLUMB. Does that number embrace the country population?

Mr. LITTLE. Those are all who are in that immediate vicinity.

Senator PLUMB. You have a town, and you each have holdings in the fields?

Mr. LITTLE. Yes.

Senator PLUMB. This thousand acres of land is divided among you?

Mr. LITTLE. Yes.

Senator PLUMB. Nearly equally?

Mr. LITTLE. No. There are some stock men who do not farm—make no business of farming. There are comparatively few farmers.

Senator PLUMB. Where is your railroad station?

Mr. LITTLE. Milford is the nearest station. But we generally do our freighting from Juab, on account of the road, and it is less railroad freight.

Senator JONES. How long have you lived in that place?

Mr. LITTLE. I think I went there in 1870—nineteen years.

Senator PLUMB. You have been in this country a long time?

Mr. LITTLE. I came here in 1849.

Director POWELL. I think it would be well to have it mentioned somewhere in the record that this was the second experiment on the same stream; that the first attempt was 40 miles higher up the stream, and that it was abandoned because it was too cold.

The CHAIRMAN. Is that the case?

Mr. LITTLE. Yes. Sometimes they would plant the settlement too far up in the mountains and sometimes too far down. They have changed the canals over and over again. This is but one illustration of it. St. George would be a much more striking illustration. We have had to change our fields because of the floods of sand. They had one crop nearly destroyed by the sand coming down over our corn when it was in the shock, and also before it was cut.

STATEMENT OF G. M. OTTINGER, OF SALT LAKE CITY.

The CHAIRMAN. Are you familiar with the water supply in this locality and the modes of obtaining it?

Mr. OTTINGER. Yes. Salt Lake is supplied from City Creek for culinary purposes and lawn sprinkling. The area of the water-shed of City Creek is a little short of 13,000 acres. The average flow of the creek in ordinary times, when you have a good snow-fall, is about 10,000,000 gallons in twenty-four hours. For the last three years it has been flowing only about 8,000,000 gallons. Last year, owing to the three years of dry seasons, it has been flowing much less—5,000,000 gallons. Yesterday it was a little over 4,000,000 gallons. The creek has been lower this year than it has been since 1880.

The CHAIRMAN. What means have you taken to increase the water supply?

Mr. OTTINGER. We have increased the capacity of the creek this year 2,000,000 gallons.

Senator JONES. Yet it is below the average?

Mr. OTTINGER. Our sources of supply depend on the snow and rain fall in the mountains. When we have little snow we have a scarcity of water.

The CHAIRMAN. Are there any basins high up in the mountains in which to store water?

Mr. OTTINGER. We could make storage reservoirs, but it is hardly practicable. The only way to build reservoirs is to build large ones. *We are building* a reservoir, and it is to be so constructed that we can

run the entire contents of the creek into it. The consumption here is 4,000,000 gallons daily. We have only 3,000 inhabitants, but they use a great deal of water for sprinkling. All our lawns and streets are sprinkled.

The CHAIRMAN. You use the water of Utah Lake. How much does that cover?

Mr. OTTINGER. That would cover in the neighborhood of 3,000 acres; all this lower portion, say about two-thirds of the city. We are unable to bring the water on the high lands. We are using the creek to bring the water to the city. For culinary purposes all we have had is City Creek

The CHAIRMAN. Can you help City Creek by using Utah Lake?

Mr. OTTINGER. That is our main hold. Utah Lake is the proper reservoir for Salt Lake City. It has an area of from 10 to 20 miles, with an average depth of 8 to 9 feet. The rain-fall from June to the 1st of September is about 3½ inches. The average rain-fall is not over 17 or 18 inches during the year.

The CHAIRMAN. How much water do you put on the land for irrigating purposes?

Mr. OTTINGER. It requires a cubic inch.

The CHAIRMAN. How many irrigations do you give it?

Mr. OTTINGER. About twenty.

The CHAIRMAN. An inch deep all over?

Mr. OTTINGER. Yes.

The CHAIRMAN. About 20 inches in depth.

Mr. OTTINGER. Yes. It would require a tremendously big reservoir to impound water enough to irrigate a large area of land.

The CHAIRMAN. In irrigating in this city—of course that would not be for ordinary agricultural purposes—but in irrigating in this city, have they tried sub-irrigation?

Mr. OTTINGER. No, I do not believe they have tried that, except in one or two cases. Generally they pour the water over the land and it soaks it up like a sponge. We have about 96 miles of streets. We have about 25.3 miles of water-mains, which, taking in the business portion of the town, supplies water to about one half the town. But we are very short of water in parts of the town. It can be supplied. We can impound water for culinary purposes by a reservoir; but I do not think it would be practicable to impound water for agricultural purposes. It would be as expensive as impounding water by machinery; it would take so much. One hundred and thirteen tons of water would irrigate one acre of land. To impound water enough to irrigate a large area of land would take a big reservoir.

Senator REAGAN. One hundred and thirteen tons of water to one acre?

Mr. OTTINGER. Yes. It is hard to tell how much water is used per capita, because we are using so much for irrigating lawns. But we have 2,018 water taps. The city is using those taps and 4,000,000 gallons of water a day. Fifteen thousand persons are not drinking that water; it is used on the lawns. This year we have restricted them in the use of the water, by fixing a time for sprinkling the lawns. We are compelled to do that.

The committee took a recess until 8 o'clock.

EVENING SESSION.

STATEMENT OF JOSEPH R. WALKER, OF SALT LAKE CITY.

The CHAIRMAN. How long have you resided in Salt Lake City?

Mr. WALKER. About thirty-seven years.

The CHAIRMAN. You are a merchant, I believe?

Mr. WALKER. Yes.

The CHAIRMAN. You desire to make a statement in regard to some lakes or places for reservoirs for storing water for the use of this city?

Mr. WALKER. Yes.

The CHAIRMAN. I will state to you the condition of the law at the present time. The Government has reserved the reservoir sites and rights of way; and this reservation, as I understand the law, is for the benefit of those who shall use the water. It was made for the purpose of preventing persons occupying those sites to the exclusion of those who might wish to store and use the water. That reservation was made nearly two years ago, and rights acquired since that time are subject to the right of the Government to make these selections. If anything can be done for you by way of having the places designated as reservoir sites, Major Powell, who has authority to do that, will direct it to be done.

Mr. WALKER. There is a chain of lakes at the head of the Big Cottonwood, some sixty-eight in number, that can be made to store a great deal of water. That is the only permanent source from which Salt Lake can get water in the future. I am pleading the cause of the city; personally, I want nothing to do with it. There are four or six of these lakes, about 18 or 20 miles from the mouth of the Big Cottonwood.

The CHAIRMAN. Can you describe those lakes?

Mr. WALKER. You first commence with Silver Lake. As you go up the cañon you find Lakes Mary, Martha, and Catharine, and also Dog Lake, on the east side of Lake Mary.

Senator REAGAN. How far are those lakes from the city?

Mr. WALKER. Twenty-eight to 30 miles. There are also two other lakes called the Twin Lakes.

Senator REAGAN. Are they south from the city?

Mr. WALKER. Yes, in a southerly direction, going toward Alta, at the head of the Little Cottonwood. There are also two other lakes which lie midway between the mouth of the cañon and Silver Lake, which is 18 miles distant. These two lakes lie easterly or southeasterly from the Twin Peaks, from the range of Little and Big Cottonwood.

Senator REAGAN. You had commenced making a statement as to two other lakes. What was their direction and course?

Mr. WALKER. They went about one-half way up the cañon.

Senator REAGAN. The same cañon?

Mr. WALKER. The same cañon—say 9 miles—and they lay on the south side of the cañon under the Twin Peaks and on the range between Big and Little Cottonwood.

Senator REAGAN. What is the size of those lakes?

Mr. WALKER. The size of Silver Lake is possibly 400 acres. The size of the Twin Lakes is perhaps three-quarters of a mile in length, if you consider the two lakes as one, which they would be by putting up an embankment. They are possibly from one-half to five-eighths of a mile in width. Lake Mary, by making it a storage reservoir, could be made to cover possibly 100 acres. Lake Martha could possibly be made to cover 100 or 120 acres. These figures, of course, are guesses, but I

think they will approximate the proper figures. Lake Catharine would cover perhaps 60 or 75 acres.

Senator REAGAN. Are those lakes situated so that they could be connected one with another?

Mr. WALKER. They would have to be made into separate reservoirs, except as to Twin Lakes. The Twin Lakes could be made into one large reservoir.

Senator REAGAN. The nearest of them is about how many miles from the city?

Mr. WALKER. The nearest are the two lakes which lie under the Twin Peaks, distant about 17 miles from this city. The other lakes will be an average of from 28 to 30 miles distant.

Senator REAGAN. What is the character of the country over which a ditch would have to be made?

Mr. WALKER. There would be no ditch required because it has a natural outlet, which is Big Cottonwood Creek or Cañon. The country in which they lie is a granite country; some of the basins you may see here in a granite formation. The water would flow down the cañon right to the mouth of it, which is, say, 13 miles of transit; there the water would flow down naturally.

Senator REAGAN. So that you would have to provide artificial conveyance only from the mouth of the cañon to the city?

Mr. WALKER. That is all. The lakes are used for irrigation on the Big Cottonwood from 7 to 12 miles distant. That whole country is watered by a natural flow of water. What I have in contemplation is the raising of the dam; that is to say, putting a dam in front of each of them to get a surplus of water.

Senator REAGAN. What water-shed is there to supply water to those lakes?

Mr. WALKER. The water-shed is the entire basin of the Big Cottonwood to the backbone of the Wasatch, and the spurs that enter into the Big Cottonwood cañon.

Senator REAGAN. Would they furnish water for the country that is now in the neighborhood, and then for the city?

Mr. WALKER. I have no doubt of it. There is a large watershed there. It is the region of perpetual snow. The altitude of Silver Lake is 8,600 feet, and the other lakes I have mentioned are 10,600 feet.

Senator REAGAN. Your idea is to increase the capacity by dams?

Mr. WALKER. Yes; so as to have the lake take the surplus water.

Senator PLUMB. Would your plan be to have Congress make the expenditure?

Mr. WALKER. Yes; that is my view of it.

The CHAIRMAN. Has not the city of Salt Lake the power to make the expenditure without special act of Congress?

Mr. WALKER. I think so, although the debt of the city is climbing up pretty well. It is now something like $400,000, and the next $50,000 will make it $500,000.

The CHAIRMAN. Is there a large amount of water from the Cottonwood that runs to waste in flood time?

Mr. WALKER. Yes; there is a vast amount. Much more runs to waste than is utilized.

The CHAIRMAN. Your idea is to save that surplus in those lakes?

Mr. WALKER. Yes; by storage. The material of the very best class is right there—granite blocks of any size you want.

STATEMENT OF JOSEPH D. JONES, OF PROVO CITY.

The CHAIRMAN. What is your occupation?

Mr. JONES. I am probate judge of Utah county.

The CHAIRMAN. Do you live near Utah Lake?

Mr. JONES. Yes; on the east side of it.

The CHAIRMAN. Have you given your attention to irrigation in this Territory?

Mr. JONES. Yes.

The CHAIRMAN. Have you made any investigation of the subject?

Mr. JONES. I have, by looking through the county.

The CHAIRMAN. State to the committee the results of your investigation.

Mr. JONES. I have here a map of the entire county, showing the irrigation system and the natural springs.

The CHAIRMAN. What county?

Mr. JONES. The county of Utah.

The CHAIRMAN. Does it adjoin Salt Lake County?

Mr. JONES. It joins Salt Lake on the south. This map is drawn on a scale of 1 inch to the mile, and shows the land that is irrigated.

Senator REAGAN. Can you designate where those lakes are that Mr. Walker spoke of?

Mr. JONES. These lakes are south of those that Mr. Walker spoke of. This section of country lies south of that about which he spoke. This map shows the summit of the mountain range, which is also the boundary of the counties of Wasatch and Utah. It shows the watershed that supplies Utah County with water down through these natural streams. It also shows where natural reservoirs exist; that is to say, the places where reservoirs may be constructed. The section of country on the east side of Utah Lake is pretty much all cultivated in ordinary seasons, when there is an ordinary supply of water. The blue lines on the map represent the artificial canals. This district of country on the east side of the lake is pretty well watered and the majority of it is now under cultivation; but there are a number of acres there of good arable land that could be brought under cultivation with an increase of water supply. The committee on compilation has found there is sufficient water going to waste during the winter and spring months, if properly taken care of, to water all the arable land in the county, with the exception of that district on the west side of the lake. There are no mountain ranges there that furnish sufficient water. The only way to get water there would be to provide artesian wells. I have a table of statistics here that the committee has prepared.

Senator PLUMB. What proportion of land is not irrigated that can be irrigated?

Mr. JONES. There are 69,166 acres that are under cultivation in the county. There are 225,540 acres that are accessible for cultivation and could be cultivated if there was sufficient water. There are 308 cubic feet of water per minute in all the natural springs in Utah County at low-water season. There have been 28,985 acres of crops lost this season for want of water—it being an unusually dry season.

Senator PLUMB. Nearly one-half of the entire acreage under cultivation?

Mr. JONES. Yes; there are 662 miles of main artificial canals in the county leading from these natural springs, as represented here upon *this map.* We find in pretty much all these cañons shown here that

there are reservoir sites, in which water can be stored, and that there is water that goes to waste during certain seasons, all of which could be stored. There are a number in Provo Cañon in particular. I will mention the largest one. It would be at the head of the cañon, and at the lower end of what is known as Provo Valley. There can be a reservoir built there 4 miles long by a mile or a half wide, with a depth of perhaps 30 feet. As to the depth, of course a great deal would depend on the height of the dam.

Senator PLUMB. Is any of this land irrigable that is marked above these valleys?

Mr. JONES. No; that is a very rugged country. Here [indicating] is the Provo country, and there are the reservoir sites designated on the map, in green. There is very little fall in the upper end of the cañon. That Provo River drains a country about 60 miles by 30.

Senator REAGAN. Are the Cottonwood streams drained into this lake?

Mr. JONES. No; they come into Salt Lake County. This district of country, shown on this map, lies south of that. These two large plains that you see in the western side of the county are good arable land, but there is no water.

Senator REAGAN. The portion of the land intended to be irrigated by the Bear River Canal is not shown on this map?

Mr. JONES. No.

The CHAIRMAN. As to the White Lake, to what extent could it be used for a reservoir?

Mr. JONES. It will do for 130 square miles.

The CHAIRMAN. Can the water supply be increased by damming that; by making a reservoir of it?

Mr. JONES. Yes.

Senator JONES. Where is the Jordan River on that map?

Mr. JONES. On the north [indicating the river].

The CHAIRMAN. What are the difficulties about raising the Utah Lake?

Mr. JONES. There is no difficulty except that if it were raised 6 or 7 feet it would overflow a good deal of very valuable land, on the east and south particularly. If it were raised to any great extent it would flow over those lands unless it were diked.

The CHAIRMAN. When designating the land that could be brought under cultivation, you included the making of Utah Lake into a reservoir, did you?

Mr. JONES. No, not for that purpose. Utah Lake is too low to be utilized by Utah County.

The CHAIRMAN. That is then for Salt Lake County?

Mr. JONES. Yes, it can be utilized for Salt Lake County.

The CHAIRMAN. Then what you have been speaking of is Utah County entirely—beyond Utah Lake?

Mr. JONES. Yes. Up at the head of the Provo River there are a number of natural reservoirs 60 miles from Provo City and in a northeasterly direction, at an elevation of eight or nine thousand feet. There are natural lakes there that are all the way from half a mile to a mile and a half in area.

Senator PLUMB. What is your suggestion as to how this additional land should be put under irrigation; that is, as to who should do it?

Mr. JONES. My idea would be for the Government to furnish sufficient lands to enable the citizens to some extent to build these reservoirs.

Senator PLUMB. Are they not able to do it themselves?

Mr. JONES. No; *the land is owned* as a rule by poor people, in five,

ten, and twenty acre lots, and they are cultivating what they can get water for easily and cheaply. In order to get any extensive improvements in the way of reservoirs it would be necessary to get all those people to go into a corporate organization or company and use labor. They have not the means.

Senator PLUMB. As to all this 235,000 acres that is not under water, can you say whether that is in private ownership now?

Mr. JONES. No, the principal part of that is Government land. That lies in the south end of the valley.

Senator PLUMB. Then your suggestion is that the Government should first help these people who own land to irrigate their land, and then to irrigate the other body of land also?

Mr. JONES. There is no way to irrigate that land on the west side except by driving wells.

Senator PLUMB. Where is this area of 235,000 acres that you say can be irrigated?

Mr. JONES. That is the land on the east side that is not cultivated, and also in part those plains on the west.

Senator PLUMB. How much on the east side?

Mr. JONES. About 75,000 acres on the east side; and it is good arable land, but it is not cultivated.

Senator PLUMB. Is that in private ownership?

Mr. JONES. Yes.

The CHAIRMAN. How do you expect the Government to get its money back if it does this for private parties, where the Government itself does not own the land?

Mr. JONES. I had not considered that feature of the case.

Senator PLUMB. That is the Government side of the case, I suppose?

Mr. JONES. Yes.

Senator REAGAN. Is this body of land on the Spanish Fork River irrigable?

Mr. JONES. Yes, that is good land. There is a good deal of land on the east side of Utah Lake that could be farmed profitably now if Utah Lake was kept down to where it is at this time. It is much lower than usual now.

Senator REAGAN. But you do not wish it kept down to where it is now?

Mr. JONES. Yes. Utah County does wish it kept down to where it is now, for the reason that it would make hundreds of acres more valuable.

Senator PLUMB. How can that be done—by diking?

Mr. JONES. By diking or by lowering the outlet of the Jordan so that the water can go off.

The CHAIRMAN. If you lowered the outlet it would get below the ditches, would it not?

Mr. JONES. I understand so, but I am not familiar, however, with the Jordan River.

Senator PLUMB. How much money would it take to enable these people to irrigate their land?

Mr. JONES. I have not made any estimate of it.

Senator PLUMB. Would they be willing to borrow the money from the Government and apply it in that way?

Mr. JONES. I think so.

The CHAIRMAN. If the Government should make these surveys and *should* show what could be done and give estimates of the cost, would *not that enable private* parties to combine and bring the water through

this Government land and occupy it; would that be of any assistance?

Mr. JONES. Yes, I think it would. I think there would be a good many companies go ahead and construct reservoirs.

The CHAIRMAN. Without Government aid?

Mr. JONES Yes, I think they would.

The CHAIRMAN. You think it would be of some service to have the reservoir site shown, and you think that that would induce settlement on the Government land which you have mentioned, or the taking up of that land to some extent?

Mr. JONES. The Government land which could be irrigated from these reservoirs is now owned by individuals.

The CHAIRMAN. Then you mean there is no Government land there at all?

Mr. JONES. Only on the west side of the lake—about 150,000 acres.

Senator JONES. That is land that you say is not irrigable?

Mr. JONES. Only by artesian water.

Senator JONES. There is no Government land that can be irrigated there?

Mr. JONES. No, I think not.

STATEMENT OF O. J. HOLLISTER, OF SALT LAKE CITY.

The CHAIRMAN. What is your occupation?

Mr. HOLLISTER. I am secretary of the chamber of commerce of Salt Lake City.

The CHAIRMAN. The committee will be glad to have such information as you can give regarding irrigation in this Territory.

Mr. HOLLISTER. The drainage basins of Utah are three, Great Salt Lake, Sevier Lake, and the Colorado River. The principal streams of the first are the Bear, in the north, the Weber, in the east, and the Jordan, in the south.

There are in this valley between the Wasatch and the lake in round numbers 1,000,000 acres of land; more than half of all the land in Utah that can be irrigated.

The streams named, with those coming in from the Wasatch, have a mean volume of about 10,000 cubic feet per second. At a duty of 100 acres to each cubic foot, it will be seen that there is water enough to irrigate the land.

Bear Lake, in the north, and Utah Lake, in the south (with Weber River in the center), are natural reservoirs, which may be so used for storage as to assure the needed quantity in the irrigating season. The towns cut no figure in the calculation, because they are included in the acreage, and their wants are not materially in excess, in proportion to their acreage, of the wants of the farming lands. The waters from the two ends can be carried to the delta plain of the Weber if that river should prove insufficient.

Utah Valley is included in the above statement. Without storage on the heads of the streams which feed Utah Lake, about 50,000 acres on those streams can not be served. Explorations made within a few weeks developed that there are several lakes at the head of the Provo, some of them covering a thousand acres. Ten of them were recently located by people living on the Provo River. Utilizing these, there is no land in the Utah Basin but that can be watered.

As to drying up Great Salt Lake by irrigating these lands, when the pioneers came here *the area of* the lake was about one-sixth less than

it was twenty years later. If all the land that can be watered were watered, it would take about one-sixth of the average inflow for the year. Were the lake then to recede to its area in 1850, one-sixth less surface would be exposed to evaporation. Diversion of the water would be offset by decrease of surface exposed to evaporation. And if this is not quite fair, much of the water used in irrigation finds its way back into the streams and the lake by percolation, and the increase of plants and foliage tends to increase the rainfall. There is no danger, probably, of the lake ever receding below its stage in 1850.

About 400 square miles of this land was under cultivation in 1877, and perhaps 600 square miles of it are now under cultivation. What is now cultivated can at least be doubled in area. The 1,500 square miles includes 40 square miles in Tooele Valley.

The diversion of Bear River will reclaim at least 300 square miles in this valley, and by storage in Bear Lake there will be rendered possible the reclamation of 500 square miles in Idaho.

The western part of Salt Lake drainage basin is not worth talking about. There are sixty tracts susceptible of cultivation, but they average less than 1 square mile each. East of the lake the rivers carry the melting snows of the Wasatch to the valleys, and fertility is the result. West and northwest of the lake, the mountains are too light in mass to store up snow, the streams are spent before summer comes, a few springs only are perennial, and the result is a general desert, dotted with a few little oases.

The principal stream of the Sevier Lake drainage basin is the Sevier River. It rises on the high plateaus 200 to 300 miles south, flows northward a long distance, then bends westward and plunges through the Pavant range, goes out on the desert, and sinks in Sevier Lake.

Captain Dutton says in Major Powell's work on the arid region, published in 1879, that the region where this river heads affords extraordinary facilities for storage of water. The top of the high mesas have numbers of large basins drained by narrow gorges cut through volcanic sheets. There is Panquitch Lake, 8,200 feet above the sea, completely surrounded by barriers, nowhere less than 100 feet high, having its outlet through a narrow cleft. By throwing a dam 30 feet high and 60 feet long in the trachyte throat of this outlet a lake would be formed with an area of 6 or 7 square miles. Thirty or 40 square miles of lake surface, averaging 20 feet in depth, might be created at slight expense upon the Panquitch mesa alone. A dam across the upper part of East Fork Canyon would create a lake of 12 to 15 square miles. Numerous reservoirs may be made at small expense in Grass Valley, upon the Fish Lake plateau and upon the Sevier plateau, and in the valley drained by Salina Creek and its tributaries. The Sevier River itself can be cheaply dammed, and several gorges can be made to overflow swampy flats above, notably at the head of Marysvale Canyon, and again just north of Van Buren's ranch.

Whatever the facilities for storage are in this high country, the land on the course of the Sevier needs them all. Between Joseph City and Juab there are 300 square miles of good land, with water; in Juab, Goshen, and Cedar Valleys there are 300 more, and west of the Pavant, on what is now "the desert," probably 20 townships, 720 square miles.

The San Pitch is the most considerable tributary of the Sevier. There are 55,000 acres of good land upon its course, and no doubt it could all be watered by use of such storage facilities as there are. They cultivate somewhat more than one-half of it.

The remainder of the Sevier Lake basin contains fifteen or twenty small

creeks, upon which there are 50 square miles of arable irrigable land. What the facilities for storage are in these cases I do not know.

The Colorado River drainage extends from the southwest corner of the Territory to the northeast corner on the southern and eastern slope of the mountains.

The streams beginning at the southwest are the Virgin, Kanab Creek, the Paria, the Escalante, the Fremont, the San Rafael, the Price, the Minnie Maud, the Uintah, Ashley Fork, Henry's Fork, White River, Green River and Grand River.

There are 800 to 1,000 square miles of irrigable arable land on these streams, about one-third of which is on the Uintah and Uncompahgre Indian Reservations. The arable lands are generally largely in excess of the water supply. There are 30 square miles on the Virgin, 38 on the Fremont, 175 on the San Rafael, 25 on Ashley's Fork, 75 on the White, 85 on the Green, and 40 on the Grand. The others range from 11 square miles down to 3.

Little is known about the facilities for storage on these streams. They flow the cañon lands, the lands available for agriculture are necessarily above the cañons, consequently pretty high; it is a region of cloud-bursts, making bad work of dams and canals, yet no doubt they are worthy of examination.

The engineers of the Geological Survey made a cursory examination of all the streams of Utah in 1877; their reports are published in Major Powell's Arid Region, to which I am indebted for much of my information on this subject.

They made the total arable-irrigable land of Utah, taking into the account, roughly, the facilities for storage, 2,262.4 square miles. It is a good deal for me to say, under such circumstances, that I believe it will ultimately be found to be more by 50 per cent., but it will do no harm to say it.

They returned 494.7 square miles as under cultivation in 1877. It is not likely that this has increased more than 50 per cent., or to 750 square miles. If, then, there are 3,000 square miles of irrigable arable land in Utah, from which I believe there is no doubt the land now under cultivation in Utah may be increased by fourfold.

The CHAIRMAN. Is there anything you wish to say regarding the project of Mr. Bothwell to use the Bear Lake and River for irrigation?

Mr. HOLLISTER. Yes; Mr. John R. Bothwell, promoter of the Bear River Canal project, and now president of the Bear Lake and River Water Works and Irrigation Company, was suddenly called east last week on personal matters of great urgency, and upon leaving he requested me to appear for him before you.

I met Mr. Bothwell for a moment in New York, where he resides, a a few years ago, but never had much acquaintance with him until he came here last winter and engaged in this undertaking. He called at my office and inquired as to what kind of a field Utah is for loaning money on farms. I believe that was last autumn, and in prosecuting this inquiry he learned of the opportunity offered by Bear River and its delta plain.

This plain was surveyed in 1856, but from the impossibility of getting water upon it without great expense it was almost entirely unoccupied in 1869, when the first Pacific railroad was completed, and the right of the railroad company to the alternate sections attached. The 20-mile limit passes very near the cañon at the head of the plain. Much of the reserved land was pre-empted in that year and later. I think there is but little public land in the plain now.

The town of Corinne was founded in March, 1869, where the railroad crosses Bear River, and the same year, procuring the needed assistance, mostly volunteer, I ran a level from the head of Bear River Cañon to the surface of the plain near Hampton's Bridge, and in connection with others endeavored to raise the money to divert the water. We sent an agent to Washington to secure from Congress, if possible, a grant of 50,000 acres of the reserved land. If we had obtained that it was our intention to try and arrange with the railroad company to give us a part of their land, in consideration of putting it all under water. With these lands we would have had a basis upon which to raise the money required. Ex-Governor Stone, of Iowa, now Commissioner of the General Land Office, was interested in that undertaking. Public opinion was growing more and more unfavorable to the land-grant policy of the preceding twenty years, however, and our application failed, or else the magnificent delta plain of Bear River would now be one of the most beautiful and fruitful places in the world.

Since those times the railroad company has sold its lands in the plain to individuals in large tracts; Mr. John W. Kerr of this city was and is the largest owner of these lands, and during the last few years he has made several ineffectual attempts to interest capital in diverting Bear River upon them. Five or six years ago I presented them upon Mr. Kerr's terms to an Amsterdam banker, who was on a visit to New York, but the enterprise failed to interest him. I have always had a disinterested interest in seeing the river diverted, because it means the increase by about one-third of the cultivatable land of this valley, which is one of the choice spots of the earth.

Mr. Bothwell was here about the 1st of last March to make a proposition to the citizens respecting the promotion of a railroad between this city and Los Angeles, and at that time informed me that he had undertaken to divert Bear River and would assuredly do it. The 4th of March last suggested to me the 4th of March, 1869, when President Grant was first inaugurated, and when the founders of Corinne, together with sundry of the leading men of this city, who drove their four-horse rigs up there and took up land about the embryo town, duly celebrated the occasion in tents on the bank of the river below Corinne. I wrote an article for the Salt Lake Tribune recalling those old times, and suggested the carrying of the water down along the base of the mountains, as well as around the plain on the right bank of the river, thus doubling the area of land to be served, or nearly so. The article closed as follows:

> North of the lands watered by the Weber there are 250,000 acres of good land, which we doubt not will average $50 per acre in value before another twenty years have passed away. This means $12,000,000 worth of land and improvements to be created on the northeastern border of Great Salt Lake. Suppose each 40 acres of it to sustain five souls, it would mean a new agricultural population of thirty thousand, and this would mean the addition of an equal or greater number to the towns in that region.

I have reason to believe that Mr. Bothwell's original scheme contemplated only the diversion of the water upon the right bank of the river below the cañon. This he had been advised would not cost more than a quarter of a million at the outside.

But after thorough examination competent engineers estimated the cost at a round million dollars. The first step towards success was the inducing of Mr. Kerr to enter into a contract which gave Mr. Bothwell, in consideration of the diversion of the water, a large contingent interest in 35,000 acres of land; similar arrangements were made with Dr. *Roche, another large* land owner. The Walker ranch was bought out-

right at a fair price for the land minus water. The Danish settlement, between the Bear and the Malad, the town of Corinne, and most of the scattered settlers and owners, were induced to enter into contracts, either agreeing to pay a stipulated sum per acre for diverting the water, and the same for its use annually thereafter, or to sell part of their land at a fair figure minus the water. Without these concessions upon the part of the land owners it is safe to say that the money required could not have been raised. The water passing the cañon was roughly measured early in the season, and it was appropriated by Mr. Bothwell for the purpose of diversion, under existing laws and customs, still earlier.

The next time I saw Mr. Bothwell he had enlarged his scheme so as to water both banks of the river and run it down under the mountains as far as Odgen, supplying the towns, and swapping it with the farmers under the canal for the streams coming out of the Wasatch, which were to be diverted latterly, so as to cover the lands above the canal to the base range. The project now involved the taking out of 2,000 second cubic feet of water at the head of the cañon, crossing a moiety to the right bank at some suitable point, and carrying it southwestward along the upper edge of the plain as far as Blue Creek, 45 miles, and the remainder down along the base of the mountains as far as Odgen, 55 miles; and this raised the estimate of cost to a million and a half.

Four months passed in working up the matter to this stage; $20,000 had been expended. About the middle of June, Bear River being at a very unusually low stage, Mr. Bothwell became alarmed lest in seasons of extraordinary drouth, when water would be most indispensable, there should not be enough passing through the cañon to supply the proposed canal—a weakness, since the strength of a chain is measured by its weakest link, which would be fatal to the entire enterprise. It is clear that if a man induces the settlement of a tract of land upon the assurance that he will supply the land with a given amount of water, and then neglects any precaution to enable him to fulfill his contract, such a man is a scoundrel.

A little previously the Malad, Idaho, correspondent of the Salt Lake Tribune, called attention to Bear Lake as a natural reservoir, already provided by nature, high up in the mountains, lying off from but near the river, and having connection with the river. I have resided in Utah twenty years, and have kept a pretty bright lookout, but this was the first mention of Bear Lake as a reservoir I had ever seen or heard. Whether this correspondence suggested the idea I know not. In any event, deeming its appropriation absolutely essential to success, Mr. Bothwell visited Bear Lake with his chief engineer, and finding it admirably adapted to the purpose, appropriated it for storage purposes, and commenced building a dam across the outlet. I do not think he was aware of the law of October 2, 1888. I believe that it has never been published until Secretary Noble sent out a copy in response to Governor Shoup's telegram.

Some farmed lands on the shore, which would be covered by damming the outlet, Mr. Bothwell made arrangements to purchase outright. With farmed lands on Deep Creek, the main feeder of the lake, or on Bear River above the lake, storage would not interfere. With lands on the river below the lake it would interfere by furnishing them with a flow of about 6,000 cubic feet per second during the irrigating season of three months in the year.

Adjoining Bear Lake there is an extensive marsh, through a corner of which Bear River runs. There are some hay lands on the borders

of this marsh, but for the most part it is valueless. Mr. Bothwell conceived the idea of draining this marsh, if practicable, with a view to its total reclamation. On the right bank of Bear River in Cache Valley there is a body of perhaps 100,000 acres of the best bench land. The use of Bear Lake as a reservoir Mr. Bothwell believed would furnish water to irrigate this land. He has not taken up an acre of it, or of the marsh, nor has he contemplated doing so; his object was and is to furnish water, and if his proceedings with that end in view, aside from their possible conflict with the law, are justly liable to be denounced as land grabbing or water grabbing, it is not clear to me why the appropriation under the laws of a quarter section as a farm, or of 20 acres as a mine, or the building of a saw-mill, a factory, or a railroad, are not equally liable to the same denunciation.

This further enlargement of the scheme raised the estimate of cost to $2,000,000 and possibly $3,000,000. The enterprise has now been incorporated, a loan secured, and a contract for the heavy work of the first 12 miles was let on the 17th instant. Millions of dollars have gone into the construction of irrigation dams and canals in California and Colorado. I have never before heard these schemes to transform the desert into fruitful fields spoken of in other than terms of commendation and congratulation.

And as to Idaho, which seems to be all up in arms about this "stealing of Idaho water" as they term it, how can the people of Idaho use the water that passes through Bear River Cañon below them? But it is the storage of water in Bear Lake above them, perhaps, which they refer to. That water it is not proposed to use in Utah unless in some season of extraordinary drought there should be less than a supply for the canal passing Bear River Cañon. The engineers of the Powell survey give the mean flow of the river at the cañon as 5,200 second-cubic feet; the canal is intended to carry 2,000 second-cubic feet, hence the river must shrink more than three-fifths below its average stage before any Utah canal or lands will draw on the reservoir at all, a contingency not likely to happen once in twenty, perhaps in fifty, years.

The river must shrink more than four-fifths from its mean flow before any Utah canal will draw on this stored water for more than 1,000 second-cubic feet. And since storage will provide a flow of 6,000 second-cubic feet for the irrigating season, 1,000 feet could be spared for this Utah canal and still leave the Idaho people a flow of 5,000 feet more than they have now.

This immense volume of water, sufficient to irrigate about 800 square miles of land, can be used only in Idaho on the drained marsh on the right bank in CacheValley, or wherever on the lower course of Bear River it is needed and can be carried.

I will add that Mr. Bothwell's real scheme is the diversion of the waters which for ages have run to waste through Bear River Cañon upon the arid arable lands of this valley. It is not affected by the Bear Lake storage feature incorporated with it, except as the latter enables him to guard against the remote contingency of a short supply for the canals which are to be entirely in this valley.

At his request I visited with him the scene of his labors in May last, although it has long been familiar to me and I came to thoroughly understand and sympathize with his views, the more thoroughly as I had long entertained similar views upon this project myself. I know that he looked forward with high anticipations to an appearance before this commission, but he was imperatively called away.

Coming now to the relations of Mr. Bothwell's scheme to the law,

they would be entirely amicable but for the law of October 2, 1888. How he is going to get along with that I do not know, and I therefore can not discuss it as his representative. From the fact that a contract for construction of 12 miles of the heavest work has been let since the law was published, I infer that he and the parties furnishing the money believe that they see some probable way to carry through their great enterprise without serious obstruction from any quarter.

The CHAIRMAN. What objection is there to his damming the lake and using it?

Mr. HOLLISTER. I can not see any except that it is against the law at present.

The CHAIRMAN. Do the people understand that it is reserved as against their use of it?

Mr. HOLLISTER. We understand that it is reserved against everybody's use of it—any lands susceptible of irrigation.

The CHAIRMAN. The Government engineers may select it. How does he know but what the Government engineers in the future may designate his land for the purposes of irrigation?

Senator PLUMB. Had he not commenced his improvements up there in advance—you say he made a dam?

Mr. HOLLISTER. He has not made any dam, and does not propose to make any, except a dam that will raise the river 3 feet.

Senator PLUMB. I thought you said he had made an improvement there?

Mr. HOLLISTER. No, the first time that he started in was about the first of this year.

Senator PLUMB. He made no improvement then?

Mr. HOLLISTER. No, he simply gave notice. He made his location and began building a dam across the outlet. His plan would furnish a stream of 600,000 cubic feet. The mountains are high and steep and there is a little water around the shores which he is going to buy, and he does not interfere with anybody above, because he fills his lake during the irrigating season.

The CHAIRMAN. The Government having reserved these places for reservoirs, can not the Government be trusted even if he does improve it?

Mr. HOLLISTER. But is he not a squatter there, under the present circumstances? If he is not, he would give a good deal to know it.

The CHAIRMAN. You have in your statute book a right of way for all ditches over the Government land.

Mr. HOLLISTER. But does not the act of Congress supersede that in this respect?

The CHAIRMAN. I supposed it was in aid of it—to reserve the lands so that private parties should not prevent the people from irrigating the land.

Mr. HOLLISTER. He is a private party. He represents a corporation.

The CHAIRMAN. I mean private parties that should prevent irrigation.

Mr. HOLLISTER. They cannot take it up for anything but irrigation. There have been a half a dozen attempts made in twenty years to irrigate that land.

The CHAIRMAN. Then, by this reservation, you consider yourself in worse condition than before. Were not those places subject to preemption and homestead and other kinds of entries before?

Mr. HOLLISTER. We could not cut any timber here under the laws.

The CHAIRMAN. No matter about the timber. The places were subject to entry. That was the only trouble.

Mr. HOLLISTER. It has been lawful for us, as I understand it, to go and appropriate water if we wanted to irrigate.

Senator PLUMB. This ditch is now in abeyance, is it?

Mr. HOLLISTER. No, it is not in abeyance, because they believe that they will have influence enough to find favor either with the President, or with Congress, or whoever it may be that controls it, to allow them to go on.

Senator PLUMB. Before this question of reservoirs was broached, or before Mr. Bothwell attempted to conceive or carry out this proposition, he still believed there was water enough. This damming of Bear Lake was, as I understand it, only by way of extra precaution?

Mr. HOLLISTER. Yes; so I conceived, but the beneficence of the scheme had some charm for him.

The CHAIRMAN. Will you state what legislation you think it necessary to have in order to have the people avail themselves of those reservoirs? The statutes have a provision giving right of way across public land for all ditches. That is not repealed. What I understand by the language of the statute is that it reserves the places from sale.

Mr. HOLLISTER. Will you allow me to ask you a question before I answer yours?

The CHAIRMAN. Yes.

Mr. HOLLISTER. Does the Government propose locating the reservoirs and making ditches and furnishing the people with water?

The CHAIRMAN. I never heard of such a proposition.

Mr. HOLLISTER. Does it propose, then, to make surveys for the benefit of the people?

The CHAIRMAN. It does.

Mr. HOLLISTER. Then, I say, repeal the reservation. Give the people the benefit of the reservation and let them use it as freely as now.

The CHAIRMAN. Do you not know that there are many places occupied by private parties withheld from the people?

Mr. HOLLISTER. I do not.

The CHAIRMAN. I have just heard of several thousand acres near Utah Lake. It was to stop people from getting down to the borders of the lake, so that it could not be raised. I suppose that in the case of three-fourths of the good reservoir sites in the arid region you will find that people have come down so low that you have to condemn the property in order to use it at all.

Mr. HOLLISTER. That is because the Government did not start in at it twenty years ago. Since we were informed that you were coming the water commissioners at Big Cottonwood, prompted by the dry seasons, have gone up and located these lakes at the head of Big Cottonwood. They do it for themselves. Is not that all right? Others have located others. I have tried to get the city of Salt Lake to locate Utah Lake as a reservation. Would not that be all right?

The CHAIRMAN. If it had not been withdrawn from sale of what use would be your location? As long as the Government is offering the land for sale can you reserve a place for a reservoir unless the Government does it for you?

Mr. HOLLISTER. The places where you will build your reservoirs are up in the mountains. Nobody will own them for any purpose. The only way to use this as a reservoir is to cut down a throat and let the water come out in the irrigating season, and then in the dry reason shut up the gates.

The CHAIRMAN. Are you perfectly sure that when you come to raise *Bear Lake by* reservoir there will not be private land that will have *owners to be bought off*?

Mr. HOLLISTER. Mr. Bothwell expects to buy. There is not much of it, but whatever there is he would buy, and, if the Government is going to make a reservoir, it would have to do the same thing.

The CHAIRMAN. Then you think it was wrong for the Government to reserve whatever land it had there?

Mr. HOLLISTER. It would be well enough to do that if they had not reserved everything. Now, a man can not take up an acre of arid land in any State or Territory according to my idea of the law.

The CHAIRMAN. I am not speaking of the reservation of the land below, but of reservoir sites. As to the reservation of lands below, we will have to have some legislation.

Mr. HOLLISTER. There should be some legislation that will enable people to take these lands when wanted.

The CHAIRMAN. But so far as the reservoirs are concerned, what do you want the Government to do with regard to the sites? Do you want to give the sites to private parties or have the Government to keep them for the people?

Mr. HOLLISTER. I do not suppose I am entitled to speak for the people of the West; but I say I want the Government to let them be; to keep hands off.

Senator PLUMB. That is what they have decided to do.

Mr. HOLLISTER. People have lately built a great ditch in California. This improvement up here is to cost three or four million dollars. The Government will not do that work. Wherever there is a chance for it to pay private enterprise will do it.

The CHAIRMAN. The Government does not propose to do it. What do you want done about the places where the reservoirs are? Do you want to have the land sold by the Government?

Mr. HOLLISTER. You are not selling reservoir land. You are not selling Bear Lake.

The CHAIRMAN. Have not some of them got on land that you want for reservoir purposes?

Mr. HOLLISTER. Yes; that is because we did not get there in time.

The CHAIRMAN. Then, do you want that to happen in every place and have to buy people off?

Mr. HOLLISTER. I think you will find that the lands that can be used for reservoirs in this country are not wanted by anybody for any other purpose.

The CHAIRMAN. Name some of the places where you do not want them.

Mr. HOLLISTER. Up on the basalt tops; for instance, there is one place to store water enough to irrigate a thousand square miles of land.

The CHAIRMAN. You are the first man I have met who did not think it was a good thing for the Government to reserve these sites so that the people should not have to buy them out when they wanted to build a reservoir.

Mr. HOLLISTER. If you had stopped at reserving "sites," I would not object.

The CHAIRMAN. It is Congress that has done that.

Mr. HOLLISTER. Then you admit that it is not what you want. What objection would there be to the Government making this examination and publishing it, and letting the people have the advantage of it as they go along?

The CHAIRMAN. That is exactly what they are doing, and they do not propose to do anything else.

Mr. HOLLISTER. Then, that is all right. We shall be very glad to have that done.

The CHAIRMAN. That is all they propose to do. They do not propose to construct reservoirs.

Mr. HOLLISTER. We do not know anything about this land now, except what we learn from engineers.

Senator PLUMB. Do you understand that you have not now the right to go on this reserved land to put up a dam there?

Mr. HOLLISTER. I can not see how a man can put a million dollars in such a thing. It seems to me that he has got to have a special act of Congress to do it.

Senator PLUMB. I have no doubt of it.

Senator REAGAN. The information this committee is trying to collect now is intended to enable Congress to determine what would be a wise disposition of that land and that water in the future.

Mr. HOLLISTER. Yes; but meanwhile you prevent our people from making use of it.

Senator REAGAN. Temporarily; but is not that better than letting monopolists take up the water?

Mr. HOLLISTER. I don't see how they can monopolize it.

The CHAIRMAN. The Government of the United States never took any advantage of any legitimate enterprise. For seventeen years the miners of the west coast took and held possession of the mines as trespassers. Under the law they were trespassers. The Supreme Court of the United States held them to be such. Yet the Government confirmed their rights. And if persons go on now and improve these water sites or reservoir sites, they will undoubtedly be let alone and will never be disturbed.

Mr. HOLLISTER. If you carry out the same principle and recognize the squatter's right on the public land, then it will be all right. What you have said about the mines is true, but this is a new thing, and I do not think these gentlemen who are putting up their money ought to be left in that position.

Senator REAGAN. You think the law is wrong; but this committee has no power to right it.

STATEMENT OF F. A. HAMMOND, OF SAN JUAN COUNTY.

The CHAIRMAN. Where is San Juan?

Mr. HAMMOND. San Juan is in the extreme southeast corner of the Territory; it lies principally between the Colorado and the San Juan Rivers.

The CHAIRMAN. What can you tell us about irrigation?

Mr. HAMMOND. There is a small range of mountains there called the Blue Mountains, and the Elk Mountains situated half way as to north and south, and extending east and west. It is probably not more than a hundred miles all around the base of those mountains. At the south base there are fine mesas of land in an excellent climate and of good soil. Some of them are 30 miles long, and from 3 to 7 miles wide. The little streams that come out from the base of the mountains and that sink in these dry places would, if held back and stored, irrigate these beautiful tracts of land. Two on the south are called Johnson and Recapture Creeks, but they lie down in these dry washes from 100 to 300 feet deep. The sides of these dry washes are perpendicular. If you get into one of them you have to go sometimes 20 miles to get

out, and at times the water rushes through there, 15 to 29 feet deep in a solid column. Those are what cause the washouts that you read of on the railroads. Those two creeks could be dammed up and brought out on a level reservoir. The soil would admit of it, being a clay formation. It would hold water like a bottle. I am not able to say, however, which would be the cheaper—to hold the water there and store it, as in a natural reservoir, or to build a reservoir on the mesas. It would not take a large amount of money, however, to handle these two streams.

The San Juan River has been an elephant on our hands. We have operated it ten years, and it has cost us upwards of $100,000 to keep up a 7-mile ditch with about 700 acres of land under it. We have had three surveys made, three different times, at three different locations, in order to attack more land higher up. The formation of the San Juan River bank is of quicksand. It dissolves when the water comes in contact with it. It is thick with mud. Streams in western Colorado go into it, such as Los Animas and the San Pedro and the La Plata and others. As it goes down Utah it is full of mud and is almost thick enough to make adobe out of it. With every little shower the mud comes down. There are three streams that run continuously, and afford a great deal of water during the freshets, during the melting of the snows on the higher levels and mountain-tops, which are probably 5,000 feet higher than our level where we are running these ditches. The cañons are deep and afford a good deal of snow during the wintertime, but when the warm season comes on it goes down in a rush. And even in the dryest season—such a season as this, for example—we have water enough for 340 acres. The South Montezuma stream irrigates quite some portion of land. Adjacent to these streams there is excellent land.

Senator REAGAN. What is the elevation of these valleys?

Mr. HAMMOND. Right where I am living, on the San Juan, it is about the same elevation as Salt Lake—about 4,050 feet.

Senator REAGAN. What is the population of San Juan County?

Mr. HAMMOND. If we were to include the Indians, the population would tally up pretty well; but at present there are not more than forty-five families in the entire county. Perhaps three hundred cowboys are there, who run large herds of stock. It is more a grazing country than a farming country, and that is caused by the want of water. We estimate that there are 600,090 acres of good arable land there. That is a very low estimate. I have traveled over it, and I know there is that much.

The CHAIRMAN. Would Government surveys and estimates of cost for storage reservoirs, etc., be of any use to you in that region?

Mr. HAMMOND. They would be of great use. They would tell us what we have and what we might have to expend if we were able to expend it. I judge that $50,000 would put us in shape there to irrigate fine tracts of land. We could carry that water anywhere along under a 6,000-foot level.

The CHAIRMAN. If such surveys and investigations were made as to determine with reasonable certainty what might be done with these different streams, how water might be stored, and so on, do you think the settlers would combine together and utilize that information to some extent?

Mr. HAMMOND. We would be most happy to do it, but I am afraid the sinews of war would be too weak to accomplish anything. Imagine forty-five families! Sell them out, and the entire thing would not be worth $25,000, perhaps.

The CHAIRMAN. But would others come in to help you? If the facts were known would you be likely to utilize the information which the Government supplied?

Mr. HAMMOND. Yes, I believe that would be done as far as possible. I have endeavored, in the last five years, in connection with my friends up in the north, to induce some of our wealthy men to take hold of the thing, but without surveys, and without any data upon which to work, capitalists fight shy of it. I know of no part of Utah, south or north, where there is a finer chance for storing water, or a finer chance to hold water on good land. We have a good deal of poor land in Utah, but down there we have an excellent quality of land.

Senator REAGAN. What crops do you raise there?

Mr. HAMMOND. Down by the river we raise corn, squash, melons, beans, and, about the mountains, the cereals are raised. The climate is about like that of Ogden. There are natural reservoirs in these deep cañons, breaking down through the mountains, perhaps 50 feet wide. Building up a solid dam there would store quantities of water almost beyond calculation.

Senator PLUMB. How long have there been settlements in that county?

Mr. HAMMOND. Ten years.

Senator PLUMB. Is that the section of Utah to which it is proposed to remove the Ute Indians of Southern Colorado?

Mr. HAMMOND. The very spot.

Senator PLUMB. What portion of this county of San Juan is covered by the agreement between the commissioners and the Indians last year?

Mr. HAMMOND. All except a narrow strip on the stream north of the line, perhaps a strip 25 miles wide, as near as one can guess at it by traveling over it. I traveled with the Commission that had the matter in charge. In investigating the land office here in Salt Lake, they found three patents in favor of the Pittsburgh Cattle Company located on the south base of the Lascelle Mountains—the hunting ground of the Southern Utes. When they heard that, they ran the line from Bluff city until it strikes the Colorado line, and then it goes out north. That cut off the Pittsburgh company, to which they strenuously objected. It turned the Utes on to those lands to hunt in the summer.

Senator PLUMB. You are willing that the Utes should come there?

Mr. HAMMOND. Yes; if they pay us for it.

Senator PLUMB. Are your lands there included in that arrangement?

Mr. HAMMOND. Yes, but we are "squatters," and we have only Hobson's choice. All we want is to be paid for our improvements.

Senator PLUMB. You say that you have spent perhaps $100,000 for irrigating there?

Mr. HAMMOND. On one canal; and now the ditch is dry. Away went the river, and left us high and dry two years ago.

Senator PLUMB. You say that the entire possessions of these people would not amount to $25,000?

Mr. HAMMOND. I did not wish to be so understood. I mean that to all those who are there it would be a heavy tax to raise $25,000 out of their income—whatever they have there.

Senator PLUMB. Do you mean the total of what their possessions were appraised at that?

Mr. HAMMOND. I do not. That would be something like $50,000. This Bluff Canal figured so largely that every farmer in that county *almost had an interest* in it. It was a joint stock affair.

Senator PLUMB. Then they must have spent much more than they have left?

Mr. HAMMOND. Most assuredly they have. It was reported by Mr. Childs that it was not a valid claim against the Government because it had gone down—it had been washed away into the gulch.

Senator JONES. I infer from what you say that you are rather sick of your enterprise?

Mr. HAMMOND. I am not sick at all; if we can only get water. It is as good a country as any in Utah, if we only had water.

The CHAIRMAN. But I understand you that the river has gone away and left you?

Mr. HAMMOND. Yes, it has left us high and dry.

The CHAIRMAN. Is that likely to occur at any time?

Mr. HAMMOND. That is an exception; the oldest inhabitant did not know of the river being so low before.

The CHAIRMAN. If your people can not make a living, how do you expect the Indians to live there?

Mr. HAMMOND. They can put in more time than we can at chasing jack rabbits.

STATEMENT OF W. R. SMITH, OF DAVIS COUNTY.

The CHAIRMAN. What is your occupation?

Mr. SMITH. I am a farmer and a stock raiser.

The CHAIRMAN. Have you considered at all the subject of irrigation and water supply in this valley?

Mr. SMITH. To a certain extent.

The CHAIRMAN. Will you please state to the committee what conclusions you have arrived at in this matter?

Mr. SMITH. I am satisfied that there is an opportunity, if means were expended, to store a good deal of water in this country.

The CHAIRMAN. Describe the area within your knowledge.

Mr. SMITH. I am interested in the construction of a canal from the mouth of the Weber River coming around into Davis County, which has cost $150,000. This year and last year being exceptionally dry seasons, the water has failed in the Weber River, so that the canals that would usually have been full of water at this time of the year are now dry. Within the last month myself and another person went to the head of the Weber River for the purpose of looking up reservoirs and observing the opportunities of storing water to relieve the people below in such seasons as the present. We found a few small lakes at the head of the Weber, which we went up to see. We also noticed places below the head where we thought reservoirs could be made. Our conclusions under the circumstances were that in a season like this all the water we could store with safety up that river would not amount to anything to us in Davis County. There was so much land taken in and cultivated above our canal that it would take a regiment of soldiers, if we took the water stored there, to get it down where we could use it.

The CHAIRMAN. It would be of no use to you?

Mr. SMITH. No. We would have to keep it from being turned off. There is a large quantity of land brought into cultivation every year. We found the Sevier River dammed at three points, and it was only what seeped in through the bank that could be got below.

The CHAIRMAN. Would anybody be benefited by storage?

Mr. SMITH. Only *those up at the* head. Those having small farms

elsewhere and having families dependent on them for a living would find it of no advantage.

The CHAIRMAN. If the water were kept up there would it be beneficial to anybody?

Mr. SMITH. Yes, I think it would. The water can be stored to a certain extent, but we did not find a place where the water could be stored with safety so as to be of any use to us who were below.

The CHAIRMAN. Is Weber River the river which is followed up by the railroad?

Mr. SMITH. Yes; it heads near where the Provo River heads. We thought that if we had a reservoir to store the water in the spring we could improve our lands very much.

The CHAIRMAN. Then you think that the extent of country that could be benefited would be considerable and might avail itself of the information which surveys would afford?

Mr. SMITH. Yes.

The CHAIRMAN. You think that reservoirs would help the country generally?

Mr. SMITH. They would help a great deal above, and in the usual and ordinary seasons, such as we have had for say ten years back (with the exception of the last two years), there would be no lack of water for irrigating purposes.

The CHAIRMAN. A ditch coming from the Weber has been supplying you with water?

Mr. SMITH. Yes; we have had no failure, except the last two years. Then we have failed almost entirely.

The CHAIRMAN. Would surveys be of use to your people in determining where to locate reservoirs?

Mr. SMITH. Undoubtedly. We found one reservoir site in the branch of the Weber River—a valley that is narrow at the lower end, and with perpendicular rocks and sides, probably 100 feet high—the widest place across being 120 feet. You can build a dam in there that would raise the water 100 feet up, and with very little expense. It would probably form a lake three-fourths of a mile wide and two miles long.

The CHAIRMAN. If the Government should make surveys and designate the proper points for reservoirs would the people probably combine to utilize them?

Mr. SMITH. I think they would, especially to utilize this one in Cañon Creek, because, below these narrows there are settlements in Cañon Creek that have suffered materially by reason of not having a sufficient amount of water. The only natural reservoirs that I know of that amount to much are Utah Lake and Bear Lake.

Adjourned to meet on Tuesday, the 20th instant, at 10 o'clock a. m.

SALT LAKE CITY, UTAH, *August* 20, 1889.

The committee met pursuant to adjournment.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF F. H. NEWELL, OF U. S. GEOLOGICAL SURVEY.

The CHAIRMAN. State to the committee how long you have been engaged in the examination of Utah; what your conclusions are as to irrigation within its limits, and what facilities it has for storing water by means of reservoirs, etc. Make your statement in your own way.

Mr. NEWELL. I came here in March, and began first a survey of Utah Lake. I made a careful survey of the shore lines and the amount of land that would be overflowed by raising the lake according to the wishes of the people. These were submitted to the Department, and then I proceeded to examine various reservoir sites in different parts of the Territory. So far my work has been wholly confined within the rim of the basin, and all my statements will refer to the country inside, although I doubt not many of them will apply to the country draining into the Colorado.

I would review a little the statements of other witnesses. The people came here inexperienced, without capital to use in the construction of their ditches, and their only hope was to join together and contribute their labor toward the construction of their ditches. Consequently they began in what appeared to be the easy places. Each man in the community took so many shares of stock and agreed to pay a certain proportion in labor, and in that way began the work of constructing ditches. Therefore these ditches were not laid out with engineering skill, and in many instances ditches were dug and abandoned, and settlements were moved because the natural conditions of the country were not suitable for purposes of irrigation, so that the first cost of these works is largely in excess of what they could be restored for, and as the ditches were constructed in the easiest places they were not constructed with a view of covering the most land. But year by year, as the settlements increased, new projects were inaugurated, and in many instances three, four, or five ditches were performing the functions that one would do. Companies were formed to construct ditches. Each company was composed of members who co-operated together in the construction of a ditch, and their co-operation was often of the loosest kind, and often there was friction, by which a great amount of water was wasted.

The CHAIRMAN. State how that may result.

Mr. NEWELL. Each company is anxious to get the largest amount of water that would flow into its ditch, and there is no official, no person, whose duty it is to apportion the water to the ditches. Consequently it is a case of the man highest up the stream usually getting the most water, and it is exceedingly difficult for the companies lower down to

force the upper ones to let water flow by their head works except by mutual agreement.

As Judge Smith stated, there is no safeguard by which the shares of the water are held to the land or to the landowners. Each person may transfer his stock, with a limited exception, to any person he chooses, excepting in cases where there is a provision that the water shall not be taken out of the ditch represented by the stock and sold to another ditch. But such sales, so far as I am aware, are very rare. Instances I have seen, but few. The share primarily was intended in most cases to water one acre; but in this season, and other dry seasons, it only watered half or a quarter of an acre. This fall in one instance seven shares only watered one acre.

With a view to collecting information for this committee and for the use of the survey the authorities here in Salt Lake kindly communicated with parties throughout the Territory, asking many questions on this subject. All the answers to those questions have not yet been received. But from those received, and other estimates, it is calculated that the area under ditch in this Territory is 600,000 acres. Of that, this summer, about one-half—300,000 acres—is actually watered; but on those 300,000 acres the largest crops have not been raised.

The CHAIRMAN. Are those 600,000 acres in the basin you are considering?

Mr. NEWELL. No. In the entire Territory. Dry farming in most cases I do not consider can be so termed. In looking into the matter you will find that while the water is not put on the land by ditches, it gets there by seepage, and it is as truly irrigation—underground irrigation—as though the water flowed in definite channels.

The question as to the duty of water has consumed a good deal of time, and has not been satisfactorily answered, from the many sides that it presents. But the conclusion to which I have come is that 1 cubic foot of water per second, flowing in the ditches, has irrigated in this dry season about 75 acres of land. In more favorable seasons the duty is far less. Another way of stating the duty is by the acre-foot. One inch to the acre is in certain parts of the Territory considered to be the ordinary duty of water, meaning by 1 inch a square inch area on the sill of the measuring flume, and not under pressure. Of course this is a very indefinite quantity, but the measurements in the cases examined make this inch equal ten to fifteen thousandths of a cubic foot; the water in the course of the season would thus cover 1 acre from 1.8 to 2.6 feet deep.

It is customary for the water masters of the Territory to divide the water for irrigating streams, and those streams are measured by the eye. An irrigating stream by actual measurement carries from 3 to 5 cubic feet per second, and in seasons of comparative plenty one irrigating stream will water an acre in two hours. Now they go an hour and a half, and even less. But by that calculation one irrigation would cover an acre 6 inches deep.

The water is generally applied by turning it on at the upper end of the field, and it is then allowed to find its way into the small grain by furrows or flooding. As a consequence, the upper part of the field receives all the water. They stop the flow when they see the water at the lower end.

The duty of water has not been large for the reason that the men who built the canals, who own them, and who originally invested in them are also the owners of the land, and their only profit arises from the products of the land; and in looking at the crops they raise

they forget the source of supply. In other words, they neglect their ditches. The only annual cost of water is 15 to 30 cents per acre, and in rare cases $3 an acre.

Senator JONES. That is after the farmer owns the water.

Mr. NEWELL. That is merely to get the water to his field each year. In other words, the actual tax is for the water right. That is to say, the care of the ditches only amounts to that per acre. So that, you see, in most of the ditches very little work is put on them, especially as this 15 to 30 cents per acre is often paid in labor, averaging about $1.50 per day of ten hours.

Irrigation by artesian wells has been discussed considerably, and many wells have been put down, aggregating hundreds, in this Territory, but the total acreage irrigated is very small. I have not been able to find a statement of over a few hundred acres. The entire supply has been devoted to household uses, watering stock, and for orchards. The actual condition in this Territory is, that all the water flowing in the streams has been taken, and more land has been brought under cultivation than there is water for its supply.

There are only two hopes for holding this Territory as it is, with the natural development: First, increased rain-fall; second, economy of water and increase of the supply by storage. Economy comes first, because stored water is always more valuable than that which flows in the natural streams, and greater care must be taken of the ditches. The stream beds are rarely, if ever, straightened or improved. In this time of low water the little water that does flow into the stream has to wet the entire bed of the stream, and a large portion of water is lost by evaporation and soaking into the ground, where in many cases it could be increased, even doubled, by intercepting the underground flow or confining that which appears on the surface within definite bounds.

There are two classes of irrigation proper in this Territory. First are towns like those of the San Pete Valley and Nephi, near Juab, in the Salt Creek Valley. The people take their water directly from the mountain streams, which flow through the towns diagonally, and ditches are often taken off at convenient points. The stream itself becomes the canal. They own it. An increase in population depends on the supply. They have no one to contend with. The people can, if they please, go to the headwaters, improve the channel, and store the water.

The other classes are those down along the Sevier River. They take the water from the river flowing several hundred miles through several counties, the water of which is subject to appropriation by the people all along that line. There they can not control the water. Bear River is similar, but I mention Sevier as the best type, as it is wholly in this Territory. The only hope of those lower down is in a reservoir system high in the mountains, and they can not make those reservoirs without some help from the Territory or from the General Government. They have called on the Survey for reservations of those upper reservoir sites, and I have been with some of the residents, some of those who are largely interested in canals, gentlemen who are high in the church, and have made an examination of the possible reservoir sites and every site that I have seen in Utah. Every large site, of more than 100 acres, has been squatted or filed upon in some shape so that the Government is only a part owner in these sites. These men feel that they must have the balance reserved to save them the expense and difficulty of acquir-

ing title. They, therefore, fully appreciate our work and are enthusiastic as to its possibilities.

The CHAIRMAN. Are those occupants where you have noticed them squatters in the general acceptation of the term, or have they legal rights?

Mr. NEWELL. Wherever the land is surveyed they have made at least declaratory statements.

Senator REAGAN. Do you mean in the mountains?

Mr. NEWELL. In the mountains, even the highest.

Senator REAGAN. Up where those reservoirs are, is there any land suitable for cultivation?

Mr. NEWELL. If the land is too high up to raise winter grain, they will turn the streams into the ground—these little basins are exceedingly fertile—and graze their cattle. They are mostly ranchers, and whatever grain they raise is a secondary consideration.

These people down on the Lower Sevier have been year by year losing their water, and when these gentlemen went up into the high plateaus they then saw the cause of it. Settlers have been year by year pushing in there where there was plenty of water and good grazing, and have been taking up the small streams. These gentlemen remonstrated, saying, "You have taken the water out of the Sevier River;" they answered, "These are our creeks, no one has filed on them." The question now comes up: How are the rights down in Sevier County and still farther down at Deseret, to be protected?

As the gentleman from Davis County mentioned last night, there is no hope of receiving any aid from Davis County. They appreciate the hopelessness of getting water 50 miles down that river without some aid. [Indicating on a map]. For instance, here are the towns that have taken up water and are depending upon the Sevier River. The green color represents irrigated land. The river then flows through the cañons, and the water comes through this portion of the country. On these ravines and depressions in the mountains settlers have come in and taken up the water, diminishing it in this portion. Their only hope is from the river which flows through this portion and comes through the gap at Deseret.

The problem we have to solve is this: How to get water. Residents have asked the survey to establish gauging stations at various points on the river to ascertain the amount of water flowing down at different times, so that the people may have some data as to the amount of water that should be due to their reservoirs. They ask more than that, however. They ask that some legislation be passed by which they can force the people at the head-waters to allow the water belonging to the older vested rights to come through. The people above have seven counties, and those below have to contend with them. There is no general system of which they are aware, except, perhaps, an appeal to the arbitration of the church, by which the water can be forced to pass these places. In the valley of the Sevier, in Sevier County, the river is taken out four times, so that the bed is dry.

Senator JONES. Taken out at four different places, you mean?

Mr. NEWELL. Yes; but when it comes out on to the Sevier Desert, about Deseret, there is apparently as much water as when it enters Sevier County.

Senator REAGAN. Notwithstanding that the water has been taken out?

Mr. NEWELL. Yes; notwithstanding that the water has been taken out. So that the hope of these people on the desert is to store water at

the lower end of Sevier County and also again before the river leaves the cañons to enter this Sevier Lake Desert.

Senator JONES. Have you examined the lakes along there and have you formed any conclusions as to whether these ideas are feasible?

Mr. NEWELL. Yes; they have been examined and reserved by the survey. I may state that the larger reservoirs on this system have been examined and reserved, and the people are preparing to construct at least two reservoirs, and probably will construct others. But now the matter before them is this question of measurement of water. Some person must establish gauging stations so that they may have some data and know where their reservoir water goes to.

Senator JONES. So as to know how this water is distributed?

Mr. NEWELL. Yes; this Territory, as far as I understand it, differs from the others in the method of distributing water in times of scarcity. In many places the system of priority of right has been interlocked with that of equal division, in this way: when water is scarce, by agreement they will determine up to what time acquired water-rights shall be termed "prior." We will say that, in a settlement, all water used before 1867 has a "prior" right. In that settlement all water used between 1867, we will assume, and 1875 has a "secondary" right. All water acquired since 1875 has a "third" right. Then they set off——

Senator PLUMB. Who are "they?"

Mr. NEWELL. The water-land owners, who are also owners in the canal.

Senator PLUMB. In what canal?

Mr. NEWELL. In any canal.

Senator PLUMB. You are speaking now of the law of Utah?

Mr. NEWELL. No, not of the law; it is a matter of general custom.

Senator PLUMB. There is no law about it, then?

Mr. NEWELL. No law at all; simply custom.

Senator PLUMB. There are no water commissioners appointed under the law of the Territory?

Mr. NEWELL. There have been such officers. The county commissioners were water commissioners, but they do not act so now.

Senator PLUMB. The law is inoperative down there?

Mr. NEWELL. Yes. By agreement the men who have used water previous to 1867 make a list of the number of acres cultivated prior to that time. Those between 1867 and 1875 make a list of the number of acres that they have cultivated at that time. Each list may include some men who have come on the prior right; and so with the second and third rights. So that one man may own 20 acres of prior right, and 40 acres of secondary right, and 10 acres of third right. In time of scarcity, then, all the third are cut off (if that be necessary), in order to supply the first and second rights. Then the second rights are cut off, if that be necessary, in order to afford a sufficient supply for the first rights.

After supplying the first rights, if water is still too scare for all, it is apportioned among them. I mention that to give an illustration of the operation of these rights where priority of right is accorded not to individuals but to groups of individuals. The opinion of this Territory is rather against the strict enforcement of the prior right, but rather in favor of a fair division, as far as it may be applicable. That is all I have to say on the general subject.

Senator JONES. Then I understand that under this proposition, if there is water enough simply to give a full supply to the prior rights,

they are to have a full supply to the absolute exclusion of the second and third rights?

Mr. NEWELL. Yes; but that full supply, by the way, is determined by the water-master, who, being elected by all the parties in interest, is more apt to apportion each man less than he thinks his full supply rather than give him an excess.

Senator PLUMB. This water-master is not elected under the law at all, but chosen by agreement among the people?

Mr. NEWELL. That is it.

Senator JONES. Is there any effort made to control this distribution by the laws of the Territory now?

Mr. NEWELL. Not that I am aware of.

Senator PLUMB. Then if this agreement were changed among the people the rights would change; in other words, there is no law that governs the matter, consequently they settle the matter among themselves.

Mr. NEWELL. Yes.

Senator JONES. It is a mere custom?

Mr. NEWELL. Yes; I will show you some of their tickets or shares, showing the time of limitation as to water rights.

The tickets are as follows:

No.—
IRRIGATION TIME TICKET.

Mr. ——— ———. Block ———, Ditch No.—, every —— from — o'clock — m., and until — o'clock — m., amount of stream —— of water in said ditch.

W. H. BROWN,
Water-master.
——— ———, *Deputy.*

PROVO CITY, UTAH, *May* ——, 1889.

No. ——
IRRIGATION TIME TICKET.

M——— ———: You are entitled to the use of the water on Block ———, Ditch No. ——, every ——— from —— o'clock — m., and until —— o'clock — m., amount of stream ——— of the water in said ditch; when you are required to discontinue to use and turn it off.

W. H. BROWN, *Water-master.*
——— ———, *Deputy.*

PROVO CITY, UTAH, *May* ——, 1889.

No. —.
TIMPANOGOS IRRIGATION TIME TICKET.

Mr. ——— ———. On —— every alternate week, from — o'clock — m., and until — o'clock — m., ——— amount of stream, all of the water in said ditch.

——— ———
Water-master.

No.——
TIMPANOGOS IRRIGATION TIME TICKET.

Mr. ——— ———: You are entitled to the use of water from the Timpanogos Ditch on ——— every alternate week, from —— o'clock — m., and until —— o'clock — m.,———; amount of stream, all of the water in said ditch; when you are required to discontinue to use and turn it off.

——— ———, *Water-master.*
Per ——— ———, *Deputy.*

PROVO CITY, UTAH, ——— ——, 18—.

No. ——
Am't of labor, ———
Am't of cash, $ ———
———
Total, $ ———
Issued to and received by
——— ———.
Date, ———, 188—

No. ——
Received of ——— ——— ——— days' labor, $———
Cash ..... ———
———
Total ..... ———
In full for his water-tax, for the year ending March 1, 188—.

——— ———, *Water-master.*

PROVO CITY, UTAH, ——— ——, 188—.

Senator JONES. You did not state what your conclusions were about Utah Lake and the basin of the Upper Sevier Lake. Have you arrived at any conclusions as to what could be economically done with those, or with Utah Lake, as to the elevation of the lake, or how it should be handled? *Is that matter* yet in abeyance?

Mr. NEWELL. I made an examination of it. At first it was thought necessary to raise the lake in order to get more water, but on more careful study I think the lake can perform its full functions best by drawing down below the natural shore lines, rather than by raising it above them. In other words, if raised above, the lake will be too large for the evaporation area. The evaporation is even now too great in proportion to the amount of water that can be taken out. My estimates show that the evaporation this spring has been twice as much as the water coming from the Jordan. If the lake is raised that proportion must increase; while if it is lowered, and the outlets consequently are lowered, the proportion lost by evaporation will be less compared with that which can be utilized. A larger stream is flowing into the lake than flows out of it, and most of that water is lost.

Senator REAGAN. To what extent would it affect irrigation on the land below there?

Mr. NEWELL. The lowering that I had in my mind was a maximum of 3 feet. If they lowered their canals 3 feet I do not think it would reduce the area of land very much. Lowering the canals 3 feet would not throw them very much out of their present line.

Senator JONES. It would not require a very great change in the present canal system to do that, would it? I have an idea that in the early location of those ditches they were probably not very judiciously located, and that if this water line were lowered much some of the earlier ditches might become utilized, they having been improperly placed at first. Do you think the water supply could be preserved by lowering the lake level 3 feet?

Mr. NEWELL. It could only be preserved by lowering the head works and improving the grade.

Senator REAGAN.—Would not that seriously affect the flow of the water below?

Mr. NEWELL. It could not, because the water is all apportioned to different canals.

Senator REAGAN. What I mean is, would the grade that would have to be adopted retard the flow of the water?

Mr. NEWELL. It would on these upper canals unless the bottoms were greatly improved. Other canals are taken out lower down the river, and of course no change in the lake could affect those.

Major POWELL. What the Senator wants to know is this; if you change the grades of the canals, if you drop the head works 3 feet, will not that affect the flow of the canals, so that they will not deliver the water?

Mr. NEWELL. It will unless that lowering of the grade is carried a long distance. I have never seen profiles of the canals, so that I can not speak from definite knowledge. But if the head was lowered 3 feet and that distributed through several miles it might be possible by improving the bed of the canals—say by cementing it and making the friction far less than at present—to deliver the water. That would require careful engineering work. But as it is now, with the moss and grass growing in them, such lowering would absolutely destroy them. Do I answer your question, Senator?

Senator REAGAN. Yes.

Senator PLUMB. You stated a while ago that there was a probability of the increase of rain-fall in the valley. On what do you base that opinion?

Mr. NEWELL. From the fact that this year's rain-fall is exceptionally small.

Senator PLUMB. That is to say, that in a year in which there is more precipitation there will be more than in a year when there is less?

Mr. NEWELL. Certainly.

Senator JONES. You mean that in an ordinary year the precipitation is likely to be more than it is this year?

Mr. NEWELL. Yes.

Senator PLUMB. You don't mean to say that there will be any increase of the rain-fall on the average in future over the past?

Mr. NEWELL. No. I prefaced my remarks by saying that my observation is based on this year of exceptional drought, and my figures are less than in an average year.

Senator PLUMB. In other words, this being a year of extreme drought, some other year would be better?

Mr. NEWELL. Yes, sir.

Senator PLUMB. You do not mean to say that there will be any precipitation of moisture in the average of years hereafter greater than the average precipitation heretofore?

Mr. NEWELL. No, I have made no statement in regard to that.

Senator PLUMB. You spoke of the taking up of lands along the margins of the reservoir sites. Has that been stimulated recently?

Mr. NEWELL. Not along the margins, but in the bottoms of these prospective reservoir sites. That has been going on for a number of years. I have noticed a number of claims within the past few years, but I do not think they are much beyond the average. This exceptionally dry year, however, has induced people to move up from the lower valleys to places where they could get more water.

Senator PLUMB. Have the surveys induced people to take up the claims?

Mr. NEWELL. I have not seen many instances yet.

Senator PLUMB. But the sites that have been taken up will have to be overflowed in order to make the reservoirs you speak of?

Mr. NEWELL. Yes.

Senator PLUMB. In other words, the settlers will have to be displaced in order to make these reservoirs?

Mr. NEWELL. Yes.

Senator PLUMB. You say the law of the Territory does not apply to the matters you have been speaking of?

Mr. NEWELL. I was speaking merely of the customs.

Senator PLUMB. The people do not carry on the operations of distributing the water under the law of the Territory, but by an arrangement of their own, which is outside?

Mr. NEWELL. Their arrangement will be in conformity with the law, I presume. I do not know. I only know what their customs are.

STATEMENT OF JOHN D. PETERS, OF BRIGHAM CITY.

The CHAIRMAN. How long have you resided in Brigham?

Mr. PETERS. I have resided there for thirty-five years.

The CHAIRMAN. Will you make such statement as you think will be useful to the committee in regard to irrigation, the use of water in this Territory, and the sources of its supply?

Mr. PETERS. I wish to make first an explanation. I received a telegram last evening when away from home to appear here at 10 o'clock, and bring some fruits and grains raised in Brigham City. I hurriedly *got a few samples* and came down. As to what other information the

committee desires of course I was not aware, but I came prepared to give any information that I can in reply to any inquiry that may be made of me. I have brought a few samples of our produce, which the committee can examine.

The CHAIRMAN. If you have lived here for thirty-five years you are thoroughly familiar with the development of irrigation. State briefly how the people did in the beginning, how they do now, and what the sources of the water supply are. Give us the early history of the irrigation work here.

Mr. PETERS. The county was settled in 1850. There were a few streams that were flowing into the valley from the eastern mountains, which, of course, provided meager supply for the land in that vicinity, and as the settlers located upon these streams they began the clearing-out work to cause, of course, a greater flow of water. The work they performed in the hill-beds and springs by clearing out did increase the flow of the water. In 1855 Brigham City was located and surveyed, and the largest stream in the county, which is known as the Box Elder Creek, was diverted from its natural channel, which is upon the site of the town, which is a dry, gravelly bench land. At that time there were probably fifty or sixty families, and it appeared as though there was hardly sufficient water for that number.

As the city became settled it appeared as though the water supply increased, and to-day there is a population in the same town of about 2,600 persons. While they do not have a plenteous supply of water they have a pretty fair supply, and do not suffer to any great extent. The size of that town, however, could be greatly increased. The number of inhabitants would be larger if the water supply were greater, because there is a considerable quantity of arid land adjoining the town. It is all good land, if it could only be brought under cultivation.

Senator JONES. Does that increase in the water supply result from a more economical use of the water, and making it go further, or has the volume of the stream increased?

Mr. PETERS. The volume of the stream seems to have increased. I am satisfied it has increased considerably, from what I can remember of the stream. I think the only reason for the increase—indeed I am satisfied that the only reason—is because of the work done in the springs and marshy places, clearing them out somewhat. I would state that the supply for Brigham City originates in large springs in a small cove or valley in the mountains. These springs as they rise seem to form a marshy bottom, and this marsh has been drained. That fact, I think, has increased the water supply more than any one thing.

There is a town commonly known as Willard, which is the next largest town in our county. That was settled about the same time, and received its water supply from a cañon. The source of supply seems to be entirely from snow, and the stream varies in proportion to the amount of snow in the mountain each year. That is not so much the case with Box Elder Creek as with the Willard. For instance, this year the Willard is almost dry. When there is a large supply in the mountains there is a large flow, and they seem to have plenty of water. The same is true as to several other streams.

Senator JONES. Is there much water running to waste, outside of the seasons of irrigation, from those springs?

Mr. PETERS. Yes; there is considerable water running to waste during the spring of the year.

Senator JONES. Is there any larger volume then than in the season of irrigation?

Mr. PETERS. Yes; there is a larger volume then.

Senator REAGAN. Would there be found any practicable means of storing that water so as to prevent waste?

Mr. PETERS. I think there would. The county is one of the largest in the Territory, and there is some arid land in it, I suppose [referring to the map]. Box Elder Creek is the largest creek in the county, excepting the Bear River. Box Elder Creek rises in a small valley about 4 miles east of Brigham. There is a small settlement in this valley known as Mantua. From this valley Brigham City gets its source of supply. These are dry runs in the summer, but in the spring of the year they have a large amount of water.

Senator JONES. And it all goes to waste?

Mr. PETERS. Yes; it runs partly into Box Elder Lake and partly into the Great Salt Lake. Box Elder Lake is now nearly dry. The reason of that is that the Utah and Northern Railroad runs directly through the lake. When the road was built there was a large stream coming from the Hot Springs that furnished its supply to Box Elder Lake. In order that it might not overflow the railroad company cut a channel, which cut off this small creek and let it go into Bear River. Fresh water is now brought on to the borders of the lake, and it produces good hay. There is a little fresh water in the spring.

Senator JONES. Bear River runs to where?

Mr. PETERS. It empties into Great Salt Lake. There is a projected canal, that you will notice on the map. That is projected by the Bear River Canal Company. The canal starts on the boundary line or about the boundary line of Cache and Box Elder Counties, and passes down to Bear River Cañon.

Senator JONES. There is a cañon that I saw from the railroad coming down from Cache Valley, where the Bear River came out; what is that called?

Mr. PETERS. That is Bear River Cañon. Then the canal divides; one portion of it runs in a northwesterly direction and covers a great portion of the arid lands lying west of Bear River.

Senator REAGAN. Is this red line on your map the proposed Bear River Canal?

Mr. PETERS. Yes; there are two branches. Another branch runs along the base of the eastern mountain of the Salt Lake Valley, in a southerly direction, to Ogden.

The CHAIRMAN. The canal, then, with its various branches is indicated by red lines on the map of Box Elder County?

Mr. PETERS. Yes.

The CHAIRMAN. Is it high enough to reach most of the arable land on the east side, or could it be taken high enough to accomplish that purpose?

Mr. PETERS. It could be taken high enough to reach most of it. But there is considerable arid land above the canal that must be irrigated, if at all, by the small streams. There is a stream called Three-mile Creek that I have not mentioned before. That furnishes water for quite a large settlement, but not nearly a full supply.

The next map that I show you is a map of Willard precinct, in Boxelder County.

The CHAIRMAN. Is it so marked on the map?

Mr. PETERS. Yes; the first map that I showed you is a copy of another county on a smaller scale. This is the second map, and is a sectional map of the section watered by the streams I have mentioned.

For instance, you will observe Willard City. It receives its supply

from the mountains. There is no place there for a storage reservoir. The supply will have to be got by digging or by some other means.

Here is one of those dry runs that I referred to; that is also to be used in making the supply for Brigham City. In this valley, known as the Devil's Gate Valley, there is a very good place for a reservoir. You will see it marked on the map. The length of the dam is given, and the height of the dam, and the acreage covered by the water when diked.

There is another very good place for a reservoir at the head of Three-mile Creek Cañon. A description accompanies the map, showing where it is practicable to store water. That report will give the information in a more connected form than I can give it.

The CHAIRMAN. Then you need not repeat in detail. As I understand you, your efforts to clean out the streams have been successful. You dig them out in the bottom and straighten the channel, I suppose?

Mr. PETERS. Yes.

The CHAIRMAN. To prevent seepage and evaporation?

Mr. PETERS. Yes.

The CHAIRMAN. And by that means you have extended the water supply largely?

Mr. PETERS. Yes. Of course, generally, we have a great amount of water, but it has been going to waste for many years. Bear River runs through our county.

The CHAIRMAN. Is Bear River sufficient to cover all the land you have?

Mr. PETERS. I think so. We have 150,000 or 200,000 acres of land in our county. That is now what you would call dry. A large part of it is farmed by what is called dry farming. A good deal of it is in the land of the Bear River and the Malad River, which is a brackish stream. That is explained in the detailed report accompanying the map.

The CHAIRMAN. You have not attempted storage in that locality?

Mr. PETERS. No. There is another town called West Portage. They have commenced a reservoir there and have put in a good deal of labor, but they are not able to prosecute their work to a finish, and have had to give it up.

(This witness produced samples of wheat, oats, rye, barley, grapes, plums, peaches, and pears, grown on irrigated land, from Brigham City, Box Elder County, Utah Territory; all being of very fine quality.)

FURTHER STATEMENT OF GOVERNOR ALBERT L. THOMAS.

The CHAIRMAN. Will you please give the committee such further information as you think will be of use to them in their inquiry regarding irrigation so far as it applies to the Territory of Utah.

Mr. THOMAS. I observed that you asked several questions with regard to the control exercised by the county selectmen over the use of water. The fact is that they exercise no control whatever. The courts, on a contest, decided that the legislature attempted to confer on those commissioners judicial powers, which the courts said it could not do. The county courts go further than this possibly, and say that the people of an irrigation district might agree on what is known as water dividers, and they could apportion among the people what they find to be their rights at the time. This apportionment is taken to the county court and there recorded. You will find probably on the records of Salt Lake County an apportionment giving the amount of water that each person is entitled to.

Senator REAGAN. Is that under the authority of any law, or from custom?

Mr. THOMAS. I should say from custom and by mutual consent. It is in effect an arbitration. I wish to make that point clear at the beginning.

Senator JONES. It seems to me that it would be well to embody that into a law.

Mr. THOMAS. I have a statement that was prepared by Prof. Marcus E. Jones, which is based on the information that accompanies the county maps I have referred to. I will read the statement.

The statement is as follows:

REPORT ON IRRIGATION AND WATER SUPPLY IN UTAH TERRITORY, 1889.

Hon. ARTHUR L. THOMAS, *Governor:*

DEAR SIR: The annual rain-fall of this Territory will not exceed 8 inches per annum, and were it not for the lofty mountains storing up the water in snow the Territory could not be inhabited. Therefore the settlements are to be found along the streams which are fed by the snow, and they are located chiefly at the bases of the mountains, though running out into the valleys as far as there is water.

The Wasatch, rising over a mile above the valleys, run from north to south through the Territory, a little west of the middle, till they reach Iron County, where they turn to the southwest and fade away in Nevada. Their average height will not fall far below 10,000 feet above the sea.

Nearly east of Salt Lake City the Uintahs, still loftier than the Wasatch, abut on them and run eastward till they pass out of the Territory. These are so close to the northern edge of Utah that we get little benefit from them, while to the south of them is an Indian reservation. Nearly due east of Utah Lake, and about 40 miles from the Wasatch, the Coal range starts from the Uintahs and runs southward parallel with the Wasatch for 160 miles, when it joins them at Panguitch Lake. These three ranges form the water-shed of Utah, the Coal range and the Uintahs forming the rim of the Great Basin, while the Wasatch performs a similar part below Panguitch. The Wasatch and Uintahs are narrow, lofty, and rugged, while the Coal range is younger, lower, and broad. The Coal and Wasatch inclose between them some of the most fertile valleys of Utah. The Wasatch reach their culmination near Salt Lake City, and, aided by Great Salt Lake, give the greatest water supply in the Territory. The streams from this source irrigate the bulk of the cultivated area of Utah.

For ease in comprehension Utah may be divided into three divisions, the moist counties, whose rain-fall exceeds 12 inches per annum, the dry counties, with a rain-fall of 6 to 12 inches, and the hot counties, with a slight rain-fall and great heat.

The moist counties are Cache, Box Elder, Rich, Morgan, Weber, Davis, Summit, Salt Lake, Utah, Wasatch, Uintah, San Pete, Sevier, and parts of Emery, Garfield, Pi Ute, and San Juan.

The dry counties are Tooelle, Juab, Millard, Beaver, Iron, and parts of others.

The hot counties are Washington, Kane, and parts of San Juan, Pi Ute and Garfield.

MOIST COUNTIES.

Cache County is situated in the middle of the northern end of the Territory, at an elevation of 4,533 to 5,000 feet above the sea. All the arable land is in Cache Valley, which lies between two ranges of mountains, the Wasatch forming the eastern boundary. The water supply is 420.13 cubic feet per second, and comes from eight streams and rivers. The whole supply will be in use next year. The area of the county is 633,600 acres, of which 43,154 were cultivated this year. One thousand, seven hundred and ten acres were dry-farmed, and 14,385 acres of crops were lost by lack of water. There are forty canals reported, aggregating 110.5 miles. The irrigating season is 122 days long, and land is irrigated 35 hours per year. The duty of water is less than a cubic foot per second to 100 acres. The average depth of snow in the mountains is 3 feet. The committee report water storage as the only means of increasing the cultivated area, since there are more than 420.13 cubic feet per second running to waste for 243 days, enough to irrigate from 50,000 to 75,000 acres. Many good reservoir sites are mentioned, but details are not given.

It is probable that artesian wells can be obtained in some parts of this valley.

Box Elder County.—This lies in the northwest corner of the Territory. The eastern *part is very fertile* and well supplied with water, but the western and greater part *belongs to the dry* counties. The area is 2,767,360 acres, of which 53,280 acres are

cultivated, and of these latter 19,190 acres are cultivated but not irrigated. The elevation of the fertile parts is 4,215 to 5,000 feet above the sea. There are 12 canals reported, length 76 miles. A branch of the Great Bear River canal is to irrigate a large area in this county. Large quantities of fruit are raised here, and still greater amounts of small grain and hay. The extensive valley of the Bear has been for half a century the recruiting place for overland travelers by team. Artesian wells are very numerous and add greatly to the productive area. Water storage is the main question here. Five reservoir sites are reported in detail, and several others in general. Bear Lake is the natural reservoir for this and Cache County, and will store all the water that will ever flow into it.

Rich County.—This lies at an elevation of 6,000 to 7,000 feet above the sea, in the northeast corner of the Territory, at the eastern base of the mountains. It is high and cold, raising only small grain, hay, etc. It lies all in one valley; is watered chiefly by the Bear River and some streams that flow into the lake. This land takes little water to mature crops, and much produce is raised without irrigation. The soil is sandy. The area of the county is 497,280 acres. There is no report from this county.

Weber County.—This lies south of Cache, extending from Great Salt Lake through the Wasatch to the headwaters of Ogden River. The best portion lies in Salt Lake Valley at an elevation of 4,315 feet, while Ogden Valley, lying along that river, lies east of the Wasatch and is more elevated. The water supply of the county comes from 17 streams and rivers, flowing 323.66 cubic feet per second. There are 117,600 acres under cultivation, of which 29,400 acres are fully irrigated, while the rest is partially irrigated or dry farmed. The soil is sandy, with clay close to the lake. Five thousand one hundred and seventy-two acres are irrigated from artesian wells. The duty of water is one cubic foot per second for 80 acres, or thereabouts. There are 25 canals, length not given. The irrigating season is 122 to 152 days long. This county is one of the most productive that we have, raising all kinds of fruit and produce that is raised in the Great Basin. The only solution of the water question here is storage. There are over 323.66 cubic feet per second going to waste for 213 days, enough to irrigate 30,000 to 40,000 acres. One reservoir site is reported of small dimensions, while others are reported from Huntsville and Wheeler's Creek, and there are numerous sites at the head of the Weber.

Davis County.—This county lies wholly west of the Wasatch, being south of Weber and north of Salt Lake Counties and between them and the lake. There is very little waste land in this smallest county in the Territory, whose arable land lies wholly in Salt Lake Valley. This county is well watered close to the mountains by numerous small streams, and lower down by multitudes of artesian wells. Many acres are not irrigated. This county is full of orchards, gardens, and fields, while roots, small grain, and hay are raised in abundance. The elevation is 4,215 to 4,500 feet above the sea. The area is 160,000 acres. The soil is sandy but with clay near the lake. There is no report from this county.

Morgan County.—This lies directly east of Davis, on the east side of the Wasatch, and occupying Weber Valley as far as Croyden. This is elevated nearly 6,000 feet above the sea, and is only adapted to small grain, root crops, and hay. The water supply is fair and the opportunities for storage good. The area is 675,840 acres, of which about 10,000 acres are cultivated. The soil is chiefly sandy.

Summit County.—This county lies almost wholly in the upper valley of the Weber, and includes Parley's Park. It occupies the angle between the Wasatch and the Uintas, and lies north of the latter. Its cultivated land is elevated 6,000 to 8,500 feet above the sea. It is cold and best adapted to small grain and hay. Much produce is raised without irrigation, and only a small amount of water is required per acre to mature crops. The valley of Weber is a succession of green fields for many miles, while on Chalk Creek and other tributaries are scattered many farms. The area of the county is 2,419,200 acres, of which 7,500 are under cultivation. This county also reports storage of water as the only means of increasing its cultivated area. Deep artesian wells might be successful here. The soil is sandy.

Salt Lake County.—This county lies between the south end of the lake and the Wasatch Mountains, occupying all of the southern end of Salk Lake Valley and lying between the Oquirrh and Wasatch Mountains. This county takes the lead in water supply and position, since the valley is 10 miles wide and 20 miles long, runs north and south, and is watered by the Jordan and by numerous large streams that flow down from the heart of the Wasatch. There are also a few streams flowing from the Oquirrh Mountains. Throughout the lower part of the valley thousands of artesian wells are flowing. The soil is sandy in the upper and clayey in the lower part of the valley. The elevation is 4,215 to 4,500 feet above the sea. The area of the county is 614,400 acres. The cultivated land is 38,587 acres. The water supply is 365.5 to 425.5 cubic feet per second, all in use. The irrigating season is one hundred and twenty-two to one hundred and fifty-two days long, and the duty of water is about 1 cubic foot to 80 or 100 acres. The rain-fall during the irrigating season is

only 7.882 inches, being more than double that in many other parts of the Territory.

There are 13,668 acres of lucerne raised; hay, 2,215 acres; small grain, 13,566 acres; roots and vegetables, 3,470.5 acres, and fruit, 1,628.5 acres. There are thirty-seven canals with an aggregate length of 213.8¼ miles. There is enough water running to waste outside of the irrigating season to redeem 44,000 acres. There are eleven reservoir sites in the mountains reported in detail, aggregating 50,250,000 cubic feet, and several others of good size not reported. There are four sites reported in the valleys, and one of them, Utah Lake, if raised 2 feet would irrigate 53,000 acres, and if raised 5 feet would irrigate 133,000 acres. But this lake can never be filled in a dry season; the total inflow last winter was only enough to raise the lake a foot, and for other reasons hereafter given it will never cut much of a figure as a reservoir. The average depth of snow in the mountains is 4 to 10 feet. The relative humidity for the year is 48.3 per cent.; during the irrigating season it is 42.3 per cent. The annual temperature is about 51.2 degrees.

Utah County.—This county lies chiefly in the beautiful Utah Valley with its large fresh-water lake in the center, 80,000 acres in area. Most of the arable land is in this valley, but there is considerable arable land on the Spanish Fork River. The elevation is about 4,600 to 4,800 feet above the sea. Though it is some higher than Salt Lake Valley it is nearly as warm, because of sloping towards the sun. The area of the county is 1,344,000 acres, of which 69,126 acres are cultivated. The irrigating season lasts about 122 days. The duty of water is reported as 40,000 cubic feet per year, but it is probably not less than 1 cubic foot per second for 100 acres. The water supply comes from fourteen streams and one river, whose flow in July was 308 cubic feet per second. There are sixteen canals reported; length, 66.2 miles. There are many artesian wells in the valley. They lost 28,985 acres of crops this year by lack of water. There are eight reservoir sites given in detail in the mountains and two in the valleys; capacity 791,000,000 cubic feet. There are five additional sites given in the valley and nineteen in the mountains; capacity not specified. Enough water runs to waste to irrigate 50,000 acres. About the same amount of rain falls here as in Salt Lake Valley. The average depth of snow in the mountains is 4 feet. The soil in this county is mostly sandy. Along the Spanish Fork River are many farms with an elevation of 5,500 to 6,500 feet above the sea whose supply of water could be greatly increased by deep artesian wells.

Wasatch County.—This lies east of the Wasatch, and the inhabited portion is west of the Coal Range, being south of Summit and east of Utah County. The settled part is a triangular valley at the eastern base of the Wasatch, called Provo Valley, since it lies along the Provo River. This is some 6,000 feet above the sea, has 18,000 acres of cultivated land, and 32,000 acres that could be reclaimed by more water. The water supply is not given, but one-half the crops were lost this year by lack of water. There are 14.5 miles of canals reported. Five reservoir sites are reported, capable or irrigating 14,000 acres. This valley raises small grain and hay chiefly. Water storage is a necessity if the present acreage is to be preserved, to say nothing of extending it. The greater portion of this county of 1,344,000 acres lies east of the coal range on the reservation. There are hundreds of acres there that produce abundant crops of hay when stock is kept off from them.

Uintah County.—This county is situated east of Wasatch, Summit, and Emery Counties. It is mostly an Indian reservation; but just south of the Uintahs is a small cultivated area not on the reservation. The area of the whole county is 4,000,000 acres. The cultivated area is 8,932 acres. The soil is partly sand and partly clay. The elevation of Ashley Valley runs from 4,400 to 5,000 feet. The irrigating season is from 178 to 198 days long, and the duty of water is given as 20,000 to 50,000 cubic feet per acre, but this is doubtless far too small. It takes a trifle more water for clayey than for sandy soil. It takes the same amount of water for small grain as for lucerne, a trifle more for root crops, and one-half as much for orchards. There were 970 acres of crops lost this year from lack of water. The average depth of snow in the mountains is 6 feet. Several good reservoir sites are mentioned. The supply of water in Green River is unlimited, and much land could be reclaimed by proper dams in this river. The supply of water on Ashley and Brush Creeks is quite limited, but could be greatly increased by reservoirs.

San Pete County.—This county occupies an elevated valley between the Wasatch and coal range, and south of Utah County. It is the valley of the San Pitch River and a part of Thistle Valley. The former runs southward from the head of Thistle Creek for 45 miles till it joins the Sevier Valley. The elevation is perhaps a thousand feet or more higher than Salt Lake Valley, and the rain-fall is less. The water supply comes from both sides of the valley in numerous small streams, but the greater number come from the east. This has been called the granary of Utah. The chief product is small grain. The irrigating season lasts 107 to 183 days. The duty of water is about 1 cubic foot per second to 90 acres. Each acre is irrigated 120 hours. Many acres of crops were lost this year through lack of water. The average depth of snow in the mountains is reported as 6 feet. Several reservoir sites are mentioned.

The area of this county is 1,164,800 acres. The amount under cultivation is not reported.

Sevier County.—This county occupies the southern part of the great valley which lies east of the Wasatch and west of the coal range, running from Thistle on the north to Panguitch on the south. This great valley, over 125 miles long, is called the San Pete on the north and the Sevier on the south. It is lowest in the middle where the southward flowing San Pitch and the northward flowing Sevier Rivers unite, and breaking through the Wasatch pass out westward upon the desert in Millard County.

The only arable land in this county lies in the Sevier Valley, which in this county is several miles wide and 50 miles long. It is watered chiefly by the Sevier River, but there are many small streams and springs coming from the mountains on either side. The river measured 70 cubic feet per second at Joseph City on July 26, 1889. No other measurements are reported. There were reported eleven canals aggregating 107.5 miles in length.

The area of the county is 993,280 acres, of which 25,000 acres are under cultivation; all but 7,000 acres are watered by the Sevier River; 100,000 acres could be irrigated if there were more water. There are 2,634 acres of lucerne raised, 11,982 acres of small grain, 710 acres of root crops and vegetables, and 178 acres of orchards.

The elevation of the lower part of the valley is about 5,500, feet and the irrigating season is 244 days long. Some fruit is raised here.

The upper part of the valley is from 6,000 to 7,000 feet above the sea, the irrigating season is 122 days long, and small grain and hay are the chief products. The soil is sandy and very productive.

There are none of the thinly populated counties that have such possibilities before them as this; for there is enough water to irrigate the whole valley if it is properly stored. The depth of snow in the mountains in winter is about 6 feet. Six reservoir sites of great capacities are reported in the mountains. All the present water supply is utilized. Deep artesian wells are possible in some parts of the valley.

Pi Ute County.—The cultivated portion of this county lies in or near the heart of the Beaver Mountains, south of Sevier County, and at the junction of the coal range with the Wasatch. The valleys are elevated and cold, being 5,400 to 7,000 feet above the sea. The irrigating season never exceeds one hundred and seventy-three days. The duty of water is not more than one cubic foot to 100 acres. The land is irrigated from twenty to forty-eight hours per annum. The water supply is 217 cubic feet per second; comes from eleven creeks and rivers, and in some localities is not all in use, while in other places 400 acres were lost and many more injured by lack of water. There are 31 canals. Ten reservoir sites are reported of such capacity as to irrigate 15,000 additional acres, more land than there is to cultivate, The average depth of snow in the mountains is 4 to 5 feet.

The area of the county is 2,368,000 acres. The cultivated area is 12,135 acres, lying in Sevier, Grass and Rabbit Valleys. But little fruit is raised in this county.

Garfield County.—The western part of this county also lies in the heart of the Beaver Mountains, and its cultivated valleys are all elevated 5,835 to 6,273 feet above the sea and cold; best adapted to hay and grain. The irrigating season lasts ninety-seven days, and the duty of water is slight; the land is irrigated but twenty-five days during the year. The water supply is not given. There are 34 canals.

The area of the county is 2,892,800, of which about 5,000 acres are cultivated.

Four reservoir sites are definitely reported, and many others are mentioned; enough to irrigate several times all the arable land in the county. Some of these sites could be used to help out Kane and Washington Counties.

DRY COUNTIES.

The larger part of these counties is arable land, and can never be reclaimed because of being destitute of any water, either present or prospective, while the eastern edge of these counties might almost be classed with the moist group.

Box Elder County.—This county lies in the northwest corner of the Territory and is the least arid of them all. The western portion has a few farms and some meagre streams, while that portion next to the lake is susceptible of artesian wells and is quite productive. The mountains in this portion are so low and lose their snow so early that water storage is out of the question.

Tooele County.—This county lies west of Great Salt Lake and Salt Lake County. It is very large, containing 4,140,800 acres, of which only 6,250 acres are cultivated, and these lie chiefly in one valley (Tooele). This valley is a broad one, lying between the Oquirrh and Aqui Mountains, from which it receives its water in eight small streams aggregating 78¼ cubic feet per second. These mountains do not rise high enough to give water all the season. This valley is being greatly developed by artesian wells.

Rush Valley is a magnificent one, being the southern extension of Tooele Valley. There are 200,000 acres that could be redeemed here alone, but there is no surface nor artesian water to be had. Reservoirs might catch some water.

Skull Valley is another large tract lying directly west of the Aqui Mountains. This is capable of artesian wells, and has a small supply of surface water. It is undeveloped.

On the western edge of the county near Deep Creek is some cultivated land.

There are 1,000,000 acres of good land that could be redeemed if there were water for it, but by fully developing all resources by storage and otherwise 100,000 acres is an outside limit of the acres that will ever be cultivated in this county with the present rain-fall.

The elevation of the valleys is 4,400 to 5,000 feet above the sea. All kinds of fruit and produce can be raised here that are raised in Salt Lake County. The duty of water is 1 cubic foot per second to 80 acres, and the irrigating season runs from 122 to 200 days. Several good reservoir sites are reported.

The average depth of snow in the mountains bordering Tooele Valley is 3 feet. The soil is so gravelly near the mountains that fully one-half of the water is lost by seepage before it gets to the fields. Water storage and fluming the canals are the crying needs of this county.

Juab County.—This county lies south of Tooele and runs from the Wasatch to the western boundary. The area is 2,457,600 acres, and fully one-half of it is level land that could be redeemed by water, but outside of artesian wells there is no hope for most of this county. Four thousand acres are reported under cultivation beneath the shadow of Mount Nebo.

All kinds of fruit and grain are raised here that the Great Basin produces. The elevation of the valleys is from 5,000 to 5,500. The average depth of snow in Mount Nebo is 3 feet. Several good reservoir sites are reported. Nearly one-half of the crops were lost this year by lack of water. Water storage and artesian wells are the only hope of this county.

Millard County.—This county lies south of Juab and runs from the Wasatch to the western boundary. This is one of the largest counties in the Territory and has the largest amount of arable land of any, if there were only water for it. The area of the county is 4,492,800 acres, and over one-half of it is good land. Artesian wells are being developed in this county, but generally the flow is so slight that the water is valuable only for drinking.

The settlements lie along the western base of the Wasatch and along the Sevier River. They are from 5,000 to 6,000 feet above the sea, and produce large quantities of fruit, small grain, and lucerne hay. The irrigating season runs from 90 to 122 days. There are 13,500 acres reported as under cultivation; 1,000 acres were reported as lost and much more as injured by lack of water this year. The soil is sandy near the mountains and clayey in the Sevier Valley. There are 42 miles of canals reported. Water storage is not only an imperative necessity in this county, but it is practicable. Much water runs to waste in the Sevier River; probably triple what is used. There are many good sites along the river where from 1 to 3 square miles of water several feet deep could be held back. Back of Scipio a natural lake, now used as a reservoir, could hold 5 square miles of water of considerable depth. It is said that the Sevier River could be turned into it.

There are several good sites in the Wasatch.

Beaver County.—This county has an area of 1,689,600 acres, of which one-fourth is good land; 9,500 acres are reported under cultivation. This county lies south of Millard and runs from the Wasatch to the western boundary. The upper valleys are 6,000 and the lower about 5,000 feet elevation.

The irrigating season lasts ninety-one to one hundred and twenty-two days. The land is irrigated twenty-nine to thirty-two hours per year. There are 45 canals, length not given. The settlements lie chiefly along the Beaver River and its tributaries.

The average depth of snow in the mountains is reported as 8 feet. The Wasatch here rises to a great height and snow lies on the mountains all the year round; 25 reservoir sites are reported in detail, aggregating 17 square miles, sufficient to irrigate 20,000 acres at least; about 10 of these reservoirs are in the valleys and the remainder in the mountains.

Iron County.—This county lies south of Beaver, on the rim of the Great Basin, running from the Wasatch to Nevada. Its area is 2,102,400 acres, and nearly half of it is arable land, some of it capable of artesian wells, but most of it destitute of water; 6,997 acres are reported under cultivation. The irrigating season is given as 142 to 269 days. The elevation of the valleys runs from 5,400 to 6,100 feet above the sea. The duty of water is given as 1 cubic foot to 65 acres in the more arid valleys and from 160 acres to more than double that in the moist valleys. The water supply comes from 8 small streams, capacity 67.63 cubic feet per second. The land is irrigated from fifteen to forty-two hours per year. If the water could be saved, from

10,000 to 20,000 acres could be redeemed 14; reservoir sites are reported in detail. Water storage is the only means of developing the agricultural resources of this county. The soil is chiefly clay.

Emery and Uinta Counties.—To this group belong parts of these two counties, which lie between the Green and Grand rivers. There are many thousands of acres of clayey soil that could be reclaimed by great canals running from these rivers, whose unlimited water supply, greater than all the rest of the Territory put together, will run to waste without assistance is given in constructing such canals. There is no part of the Territory that needs developing more than this. Very deep artesian wells might be successful here.

Emery County.—But a small part of this county belongs to the Dry Counties, still nearly all of the cultivated area lies in that section on the extreme western side of the county. This lies directly east of San Pete and Sevier Counties at the foot of the coal range.

The rainfall does not exceed 10 inches per annum. The water supply comes from four creeks and one river, breaking through the precipitous eastern face of the coal range in narrow cañons. The flow of water is 171.15 cubic feet per second. The area of the county is 5,603,680 acres. The cultivated land is 14,825 acres. The soil is a very refractory clay. The duty of water is 1 cubic foot to about 35 acres. Castle Valley is 4,500 feet above the sea, and the irrigating season is 229 days long. Little Grand Valley is 3,900 feet above the sea, and its irrigating season is 244 days long. There are 34 canals, length not given. One-quarter of the crops was lost this year through lack of water. All the water is in use.

The average depth of snow in the mountains is 4 feet. Twelve reservoir sites are definitely reported, and many others are mentioned. There is enough storage to use double the total water supply. Probably 10,000 to 15,000 acres more could be irrigated by saving the waste water. Great suffering often results from scarcity of water in this county.

All kinds of crops are raised this county, even sugar-cane, fruit, pea-nuts, etc. Figs could be raised in the hotter portions.

HOT COUNTIES.

These counties are far more arid naturally than the dry counties, since they are farther from the lofty mountains, and most of the arable parts are 2,000 or more feet lower, lying in deep valleys shut out from winds and surrounded by great fields of lava with red hills and a red, sandy soil of unknown depth. The heat here is almost unendurable and the rain-fall is almost nothing. This region is valuable for the fruit and cotton that it raises.

Washington County.—This county is situated in the southwestern corner of the Territory. The area is 1,649,920 acres. Of this, 18,892 acres are cultivated. These are situated along the Virgin River or its tributaries chiefly. It is estimated that 18,900 acres could be redeemed by an increase of the water supply. The lower valleys are 2,700 and the upper 4,000 feet above the sea. In the lower valleys the irrigating season is 197 to 228 days long, in the upper 122 to 177 days. The water supply comes from the Virgin River, four streams and many springs, capacity 191.8 cubic feet per second. In the lower valleys the land is irrigated 84 to 90 hours per year, and the duty of water is 1 cubic foot per second to 20 acres. In the upper valleys the land is irrigated 26 hours per year and the duty of water is 1 cubic foot per second to 60, 80 and 128 acres. There are 31 canals, length not given. One-third of the crops were lost this year by lack of water. It is probable that water enough could be stored to redeem most of the arable land in this county. Vast quantities of water go to waste in the Virgin River in the winter and flood time in spring. The depth of snow in the mountains is 2 to 6 feet. This county raised 30,000 pounds of cotton last year. The Sultana seedless grape is grown here and produces from 3,000 to 5,000 pounds of the finest quality of raisins. Both the hard and soft shell almonds are raised in quantities here as well as figs. It is believed that oranges can be raised here. Olives are grown in this county. Peaches and apricots from this region are very fine. They raise 4 to 5 crops of lucerne per year. A crop of small grain and another of corn are raised from the same land.

Kane County.—This county is more rugged than Washington and more elevated except along the Colorado River. It lies east of Washington. The area is 2,659,200 acres, of which 1,825 acres are cultivated, and 13,350 acres are said to be arable. The irrigating season is 182 days long, and the duty of water is from 37½ to 75 acres to the cubic foot per second. The water supply, exclusive of the limitless Colorado River, is 31 cubic feet per second. There are 9 canals, length not given. The crops are greatly damaged by lack of water. Sufficient reservoir sites are reported to irrigate all the arable land in the county. The average depth of snow in the mountains is 4 feet

The crops in this county are much the same as in the foregoing, though more small grain and hay are raised in proportion to the area cultivated.

San Juan County.—This county lies in the southeastern corner of the Territory. Most of it is now proposed to be made an Indian reservation. Its area is 5,809,920 acres. There is a narrow strip of land along the Colorado and San Juan Rivers that will produce the crops of Washington County, and has an unlimited water supply. Most of the cultivated area is 5,000 feet above the sea, near the La Sal Mountains. There are 1,025 acres cultivated. Dry farming is successful in some localities in the mountains. There are good facilities for storage of water.

Other counties.—Small parts of Garfield and Pi Ute Counties situated along the Colorado are capable of raising the same products as Washington County.

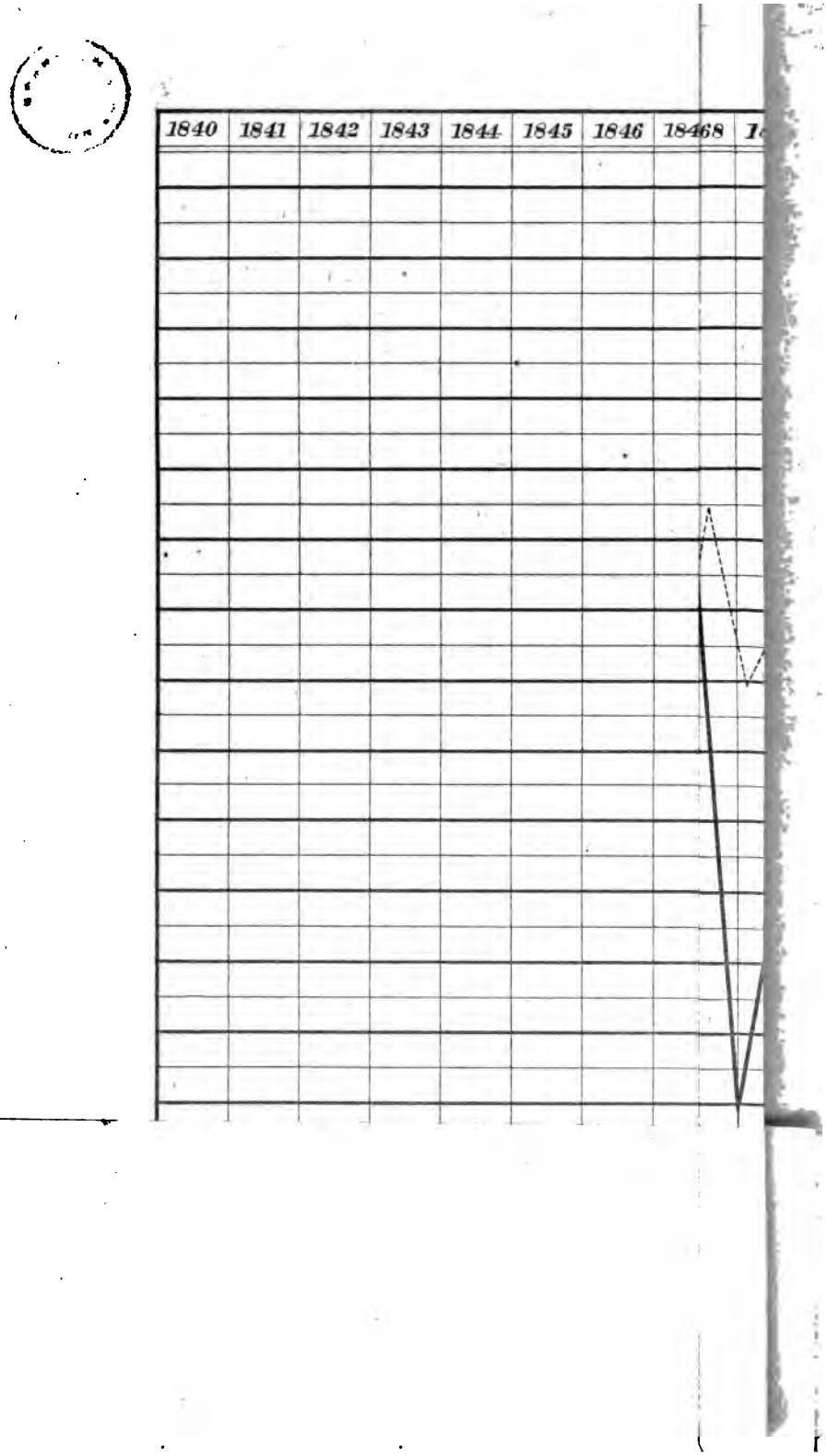
To sum up we find there are about 500,000 acres of land under cultivation at the present time. This area could be doubled from the present canals if there were more water and by new canals, etc. The various counties estimate that about 3,500,000 acres could be redeemed. This is doubtles three and a half times too large. The average depth of snow in the mountains is 4 feet. The length of the irrigating season in the moist counties is one hundred and fifty-two days; in the dry counties it is about the same in cultivated areas; in the hot counties it is about two hundred days. The returns are very unsatisfactory in this respect and must be wholly revised. The duty of water is about 80 acres to the cubic foot per second in the moist counties, in the dry counties it is uncertain, and in the lower hot counties it is about 20 acres. The water supply is about 3,000 cubic feet per second for the moist counties, 250 for the dry counties, and 250 for the hot counties; total 3,500 cubic feet per second. This is probably our minimum water supply throughout the driest years in the counties reported. If we were to add the supply in the Green and Grand Rivers this amount would be more than doubled. Almost all of the present supply is appropriated during the irrigating season and our Territory must remain at a stand-still without water storage. There are 150 reservoir sites reported in detail and nearly as many more mentioned. They vary in capacity from 130 square miles to one acre, and from 2 feet to 100 feet deep. About one-third of the crops were lost this year through lack of water.

Utah, Nevada, and Arizona are the most arid portions of the United States, and therefore the preservation and economical use of all their water supply is an imperative necessity. To show how we differ from Colorado and the East, I have prepared a diagram of the average monthly rain-fall of Salt Lake City for thirty-three years, and of Denver, Colorado, and Des Moines, Iowa, since the beginning of observations there.

During the irrigating season here Des Moines, a place where irrigation is not necessary, has a rain-fall of over 2 acre feet and Denver almost 1 acre foot, while Salt Lake has less than two-thirds of an acre foot, which would make a difference of about 11,000 cubic feet to the acre, which must be made up by that much more water from the streams to irrigate our land as well as that of Colorado is irrigated. But during the same period the relative humidity of Denver is 3 degrees higher and the temperature 2 degrees lower, which would greatly increase the amount of water required to irrigate an acre of land in Utah in proportion to that of Colorado. Besides this, Denver is nearly 50 miles from the crest of the mountains, from which a part of its moisture is derived, while Salt Lake City is but 10 miles and has a lake of 2,000 square miles in area within 7 miles on the other side. These things make Denver fairly representative of northern Colorado in general, while they show Salt Lake City as the place with at least 50 per cent. more rain-fall than the rest of the Territory (save the mountains themselves) and with a very abnormal humidity. Therefore what applies to Salt Lake in the great amount of water required per acre will apply with redoubled force in the dry and hot counties.

We have had evaporating pans located in various parts of the Territory for the last two months, and though these were of necessity placed out of the reach of the wind the evaporation averaged three-tenths of an inch per day, often running up to five-tenths of an inch. Had they been placed where the wind could have reached them the evaporation would have equaled 15 inches per month. The enormous drain upon our water supply can therefore be well understood. This militates against shallow reservoirs in the valleys. If Utah Lake were raised 3 feet its water would all be evaporated during the irrigating season if none flowed in or out. Enough to irrigate 83,000 acres would go up in the air. From records kept in the mountains the evaporation there during the same period was only eight-hundredths of an inch, and never exceeded seventeen-hundredths per day. Therefore reservoirs in the mountains are at least four times as valuable as those in the valleys. We do not yet know the rain-fall in the heart of our mountains, but it will not fall far short of 40 inches nor more than 60 inches per annum. It should be observed that though we have 2 inches more rain-fall in Salt Lake than in Denver, yet but 46 per cent. of it falls during the irrigating season while 73 per cent. of Denver's rain-fall comes when it is needed most.

The possibility of reclaiming Utah by artesian wells has been greatly overestimated. *All the wells so far obtained* have been found in some one of the basins of the ancient


1840
1841
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lake of which Great Salt Lake is the saline remainder; the area of that lake never exceeds 18,000 square miles. The clay sediment from that lake makes the impervious cap of those subterranean reservoirs, whose rims are but slightly elevated above the villages, and the reservoirs are fed from the bases of the mountains where the surface water runs over the gravel débris between the mountains and the clay rim. The average depth of these artesian wells in Salt Lake Valley is about 100 feet, in Utah Valley 200, and in Tooele about the same. In Millard County a few wells have been driven with a depth of about 200 feet and a flow of one-half to 10 gallons per minute through 1¼ inch pipe. Since no solid rock is struck in driving these wells they are very liable to clog up in a few years. The flow in Salt Lake Valley will not average 25 gallons per minute, though some wells far exceed that. A well flowing five gallons per minute will irrigate an acre of ground.

STATEMENT OF MARCUS E. JONES, OF SALT LAKE CITY.

The CHAIRMAN. The committee will be glad to hear anything that you have to say in regard to irrigation here or elsewhere.

Mr. JONES. Perhaps it is hardly worth while for me to say anything in general, but there are two or three points that I would like to correct. It has been stated, for example, that our rain-fall is liable to increase. There is no evidence whatever of that. On the other hand, the evidence is all the other way. The rain-fall of the United States in general reached its maximum in 1879 or thereabouts, and from that time to this the rain-fall, in the western part of the United States at least, has been decreasing, and it is now considerably lower. The average rain-fall of Salt Lake City for thirty-three years is given as 17.26 inches. I have worked the rain-fall out as far back as 1843 from the oscillations of the Great Salt Lake, and the average rain-fall will run but a trifle above 16 inches. My diagram [exhibiting it] represents for a period of fifty years the rain-fall of Salt Lake City.

The CHAIRMAN. Explain to the committee a little how you worked that out from oscillations. How can you get at it in that way?

Mr. JONES. I have a diagram here that will explain it. The heavy marks in the diagram are the rain-fall, while the somewhat fine marks are the oscillations of the great Salt Lake. The oscillations of that lake are about 14 inches per annum, as an average, right through. The oscillations of the Great Salt Lake follow the oscillations of the rain-fall with remarkable accuracy. That diagram begins at 1814 and runs to 1889, and the observations shown there are the ones that are recorded. We have a gauge at the lakes that is read every two weeks, and from it the oscillations are made out.

Senator JONES. What do you mean by oscillations—the rise and fall?

Mr. JONES. Yes; it rises 14 inches on an average and falls 14 inches. Last year it fell 20 inches instead of 14. This year it will fall 3 feet perhaps.

The CHAIRMAN. May not the taking out of the water by irrigation affect it?

Mr. JONES. No; there has been no appreciable effect for forty-seven years. It makes no difference apparently. All the water goes back.

Our correct record goes back to 1856. Then, from 1847 to 1856 I have made out that rain-fall from the daily or weekly paper that was published at that time, and from the diaries of old residents who wrote down whenever there was a rain. Rain is a very important thing here, and they wrote down the dates and the character of the rainfall. From that I have been able to make out this diagram with reasonable certainty to 1847. Beyond and back of 1847 I have not put in the oscillations of the lake, but I shall do so back to 1843 when I have an opportunity.

From 1847 back to 1843 I make out the oscillations of the lake in this way: When General Fremont came here he states that there was a certain percentage of chloride of sodium that was obtained by boiling down the salt of Salt Lake. The more solid that lake is the more it precipitates the less soluble elements and the longer it holds the more soluble elements. Consequently Fremont's residium being nearly all salt shows that the lake was almost saturated with salt, and in that case it must have been 4 feet lower than it is now. Fremont speaks of going across from the main-land to Antelope Island dry shod. That point is 4 feet lower than at present. Consequently the lake must have been 4 feet lower than it is now. From that I make out the rain-falls; because if that were 4 feet lower than it is now it could not have had a rain-fall of more than 13 inches and probably not more than 10. The rain-fall diagram I have made out in the hypothetical way as far back as 1814 by taking the rain-fall records of Philadelphia, Boston, Marietta (Ohio), and some other places. A diagram like this can be made up from data bearing upon other places which very nearly coincide with each other. By putting down my Salt Lake curve below these (of course ours will be from 14 to 20 inches below theirs) I find our curve follows their curve, only that it is about a year behind all the time.

The CHAIRMAN. Since you kept a record you found that it follows theirs, but that it is a year behind?

Mr. JONES. Yes; whereas the curve of San Francisco will follow their record, only that it will be two years behind. Consequently moisture goes westward, contrary to what people have supposed. When I came to where our rain-fall curve stops I could supply it approximately to the beginning of our observation. That is only approximate, but it is valuable notwithstanding. From the rain-fall curve you will see that the rain-fall of the whole country increased in 1814, when the observations began, to 1876, 1877, and 1878. That was the climax of rain-fall, not only in Salt Lake City, but in the whole country. From that time to this it has been going down. The lake is now within 4 feet of the Stansbury record of 1849.

The CHAIRMAN. Have records been kept in any part of the world to know whether this diminishing record of the rain-fall is permanent?

Mr. JONES. It apparently runs by cycles.

The CHAIRMAN. We go down a point and then come up again?

Mr. JONES. Yes. The oscillations of the Salt Lake are shown by a line on the diagram while another line shows the rain-fall. It is not altogether regular, but is comparatively so. There is a three years' oscillation and a nine years' oscillation, and there is a pretty well defined thirty years' oscillation. I am satisfied that it goes in larger and larger cycles all the time.

Senator JONES. What line is this [indicating a line on the diagram]?

Mr. JONES. The old storm line of the lake when Stansbury was here in 1849. This [another line] represents the new storm line. They are about 6 feet apart.

Mr. NEWELL. The vertical lines are years?

Mr. JONES. Yes.

Mr. NEWELL. What do the horizontal lines represent?

Mr. JONES. Inches and feet. In other words, Great Salt Lake is twelve times as sensitive as the rain-fall. Secondly, we must look to the oscillations of the lake to help us out where the records of the rain-fall are too slight to be appreciable.

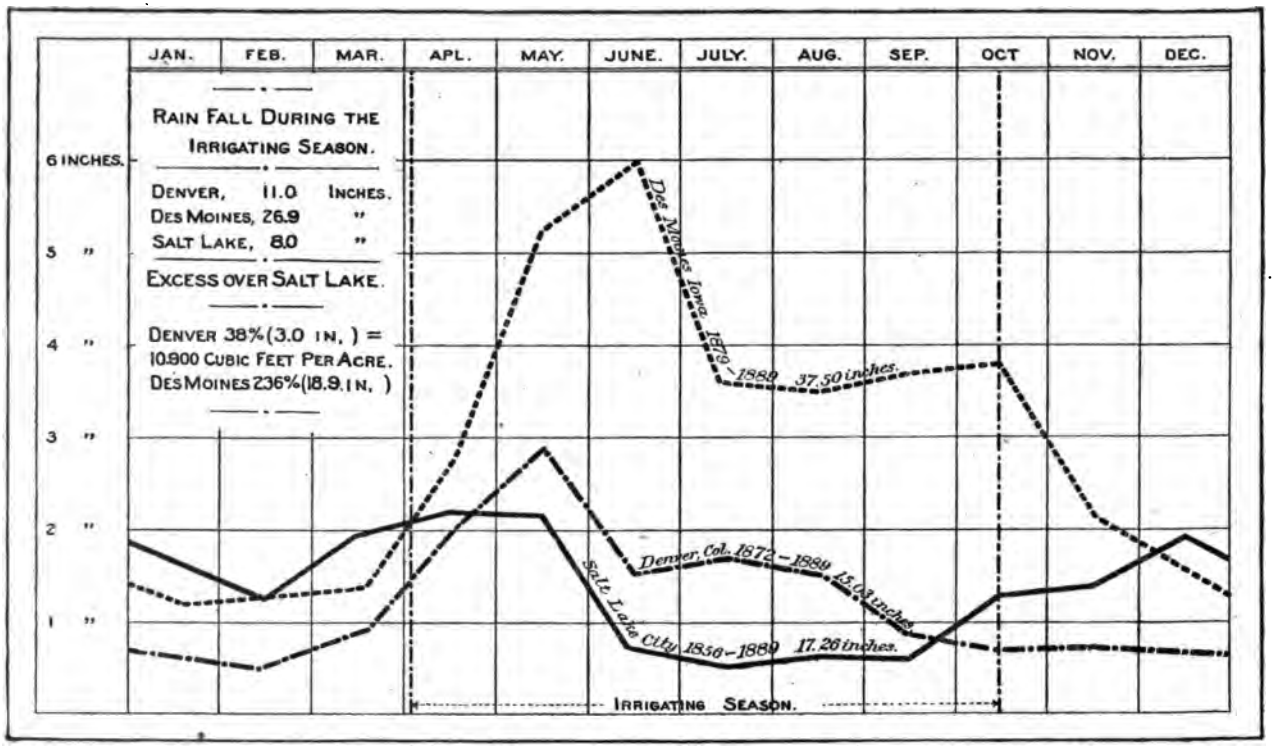


DIAGRAM OF MONTHLY RAIN-FALL (AVERAGE).

Senator JONES. I understand that the rain-fall reached that point in
year indicated on the diagram?
Mr. JONES. Yes.
Senator JONES. Then these are inches as to the rain-fall?
Mr. JONES. Yes.
Senator JONES. And they are feet as to the oscillations of the lake?
Mr. JONES. Yes.
The CHAIRMAN. Have you a written explanation of this diagram?
Mr. JONES. No; it was made for my own use. It is the result of ten
ars of study.
The CHAIRMAN. Have you published it?
Mr. JONES. No.
The CHAIRMAN. Do you propose to publish it at some time?
Mr. JONES. I suppose, sometime, when I get it complete. You gen-
men may have a copy of it.
The CHAIRMAN. We will be very glad to have it.
Mr. THOMAS. We will have a copy of it made with a description to
ompany it, and sent to the committee.
Mr. JONES. I have been compelled to take the Fort Douglas rain-fall
rve, which is not only erroneous but we do not know which way it
es. We do not know whether it is 2 inches too little or 2 inches too
ich. So, for a period of five years this diagram is liable to correction.
With regard to artesian wells there is one point that I wish to speak
I heard Major Powell explain a little to you, so that I will not need
go over the whole subject:
Lake Bonneville, of which Salt Lake is the remainder, covered about
,000 square miles. There were a number of depressions in that lake—
lt Lake now occupying the lowest and Sevier Valley being one of the
ghest ones. Then Tooele Valley and the desert out here, and others,
nnected with a smaller depression. The lake deposited sediment to
e depth of 200 feet—two layers of clay, then sand. I have a record of
veral hundred feet down, and every 6 feet downward there is an al-
rnation of clay and sand. After you go down through the first stratum
clay, which Professor Gilbert speaks of as a white clay or marl, you
me to a small stratum of sand which gives out brackish water. Then
u get to a sandstone that was evidently placed there before Lake
nneville began. Whenever you strike that you get a flow of water,
you are in one of these artesian basins. The rim of the basin is very
ght, probably never over 50 feet above the bottom of the valley. In
me places it is 60 feet; but on an average not over 50 feet above the bot-
m of the valley where the artesian waters are to be found. They get an
erage of say about 25 gallons per minute. These wells have been
nsidered to be the solution of the irrigation question in this Territory.
ut in the course of three years they cave in and people have to con-
ruct them over.
Senator REAGAN. Can you tell us how this supposed ancient lake got
e name of Bonneville?
Mr. JONES. It was named after an army officer by the name of Bon-
eville.
The CHAIRMAN. Is there a probability of their exhausting the arte-
an supply if they dig too many wells?
Mr. JONES. There is.
The CHAIRMAN. Is there evidence of their diminishing now?
Mr. JONES. Yes; every well diminishes the supply of the others. Of
ourse, there is one basin in one valley, and another basin, more or less
listinct, in another valley; and they have no apparent connection with

one another. In the Wasatch Valley it is kept comparatively full. We have perhaps a good many wells in this valley, and the supply of water is diminishing all around. It sometimes happens that a man digs a well near the center of the valley, and another man's well, as a consequence, dries up. The city has dug one, and it has dried up the water at another man's well and he has brought suit against the city.

The CHAIRMAN. What formation furnishes the large supply of artesian wells?

Mr. JONES. You must have rock. You must have the older strata. It does not matter whether it is tertiary or cretaceous rock, but if you go down far enough, and then get to 3 or 4 feet of solid rock, which is located in a proper way, and then, after getting through it, tap the artesian reservoir, anywhere from 600 feet to several thousand, you will get an amount of water coming up that is simply immense.

The CHAIRMAN. You have to get below the stratum that holds it?

Mr. JONES. You have to get below the clay and limestone. Whatever you get below that, you get a supply of water.

The CHAIRMAN. What formation supplies that water?

Mr. JONES. The Dakota supply, I suppose, comes from close to the Rocky Mountains; the Colorado supply comes, I suppose, from a place 30 to 50 miles from there.

The CHAIRMAN. Have you visited the Dakota wells?

Mr. JONES. Yes; I have been all over that section.

The CHAIRMAN. It was a matter in which the committee was much interested. There is in Dakota a magnificient demonstration of the power of these wells; but nobody gave us any account of the wells failing. Have you given much attention to the question of the source of supply?

Mr. JONES. No; I have not. My impression is that it is under the recent rocks. I have not studied up the subject enough to say positively about that. The supply, however, comes from the west.

The CHAIRMAN. Should you think that a continuous flow could be had from there on a large scale, as at present, or will the wells eventually exhaust the supply?

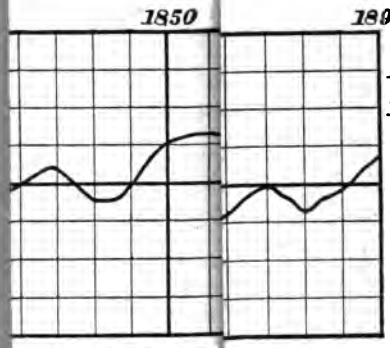
Mr. JONES. I do not think they will, except by very great multiplication of wells. Theirs are the true artesian wells while ours are not.

The CHAIRMAN. Our information was that they went through from 600 to 1,500 feet deep, depending on the altitude of the surface, and that after going through various strata they go through a hard limestone and then a loose sandstone, and that they have not penetrated through that yet.

Mr. JONES. Major Powell can tell you more about that than I can. It may be in triassic sandstone or it may be in the upper tertiary; probably the latter.

The CHAIRMAN. It has a fine flow?

Mr. JONES. I do not think there will be any decrease in the flow there caused by the increase in the number of wells. But in Utah it is very different. The artesian wells or basins are very large, some of them occupying, perhaps, 100 square miles; but the water is obtainable only around on the edge, and when you get out to the middle of the valley, you are so far away from the source of the supply that you will get only about half a gallon a minute, which is only enough for drinking purposes. We can not, therefore, depend on artesian wells in this vicinity for an increase of our water supply.



NITED STATES

H ADDENDA BY MARCUS

COUNTY STATEMENTS PRESENTED BY THE GOVERNOR OF UTAH.

The reports that follow were made in response to the annexed circular. This was prepared by Governor Thomas, at the request of Mr. Hinton, irrigation engineer, on duty with the committee:

EXECUTIVE OFFICE,
Salt Lake City, Utah, June 12, 1889.

To the County Court of ——— County:

DEAR SIRS: I have received a letter from the irrigation engineer connected with the United States Geological Survey, stating that a special committee on irrigation, appointed by the Senate of the United States, will visit Utah about the 15th of August next, and asking that information be procured for the use of the committee with a view to future legislation to be directed to the reclamation of arid lands by the storage, conservation, and distribution of the water-supply.

I, therefore, respectfully request you to furnish so far as may be possible information covering the following points:

1. The location of all streams, rivers, and irrigating canals. These can best be shown on maps, sketches or tracings, prepared on a scale of 2 inches to the mile.

2. List of canals and ditches, giving as nearly complete as possible: (*a*) name of canal or ditch; (*b*) names of owners or officers and their P. O. addresses; (*c*) date when built or first in use; (*d*) streams from which the water is diverted; (*e*) number of acres irrigated, and of cultivated land; (*f*) number of acres of good land so located that they could be irrigated by an increase of the water-supply in the canals or ditches now constructed; (*g*) number of acres that could be irrigated by new ditches or canals, and new reservoirs; (*h*) the available sites for reservoirs, either in the valley or mountains, and the probable size of such reservoirs.

In addition to the above, you are requested to reply to the following questions:

1. What is the average depth of snow in your mountains during the winter?
2. When does the irrigation season begin and end in each valley?
3. What is the elevation of each valley above the sea?
4. How much water in miner's inches or in cubic feet per second flows through each stream in your county at the point where it can be used for irrigation during the irrigating season?
5. How much water could be stored in suitable reservoirs during the rest of the year?
6. How much water is required in each valley or locality to irrigate an acre of sandy soil for each crop (small grain, grass, root crops, corn, orchards, etc.)?
7. How much water is required to irrigate an acre of clayey or alkaline soil in each valley or locality for each crop as mentioned above?
8. How often and how long at each time, is the land irrigated?
9. How many acres of crops have been lost this year from lack of water?

If the above information could be supplemented by a brief abstract from the county records of the water rights that have been recorded, it would be of special interest to the committee, and would give them reliable data showing the extent of the appropriation of the water-supply. The abstract should show: (*a*) the date of record; (*b*) name of claimant or grantee; (*c*) the amount of water claimed, appropriated or adjudicated; (*d*) nature of claim and whether a first, second, or third right.

At the last session of Congress action was taken by Congress looking to a thorough investigation of the opportunities for building reservoirs and storing water for agricultural purposes, and in pursuance of this purpose the Senate Committee will visit Utah at the time stated.

The water question is of vital interest to Utah, and I urge you to furnish as complete information as possible, and mail it to me before August 10, 1889.

Very respectfully,

ARTHUR L. THOMAS,
Governor.

REPORT ON BEAVER COUNTY.

I hereby submit the following items concerning the waters of Beaver county, Utah, also its distribution and use, together with a statement of available reservoir sites and their capacity and the amount of lands for available agriculture. I am fully satisfied also if persons were appointed to make further investigations in the mountains, that additional reservoir *sites could* be found to those already enumerated.

I also submit a plat of the Beaun and Minersville Valleys, showing the streams coursing through each and the irrigating ditches and canals taking water therefrom, the area of land irrigated from sink ditches, also the area of unoccupied surveyed land that would be available for agriculture with an increase (by storage or other means) of water and the construction of canals and other works.

In addition to the above named lands there are thousands upon thousands of acres of land lying west in "Sage Brush," "Ha Wah Wah," and other valleys that are now practically a desert, and for which some system of artesian well boring will be necessary to make them available for agriculture.

* * * * * * *

C. C. HARRIS.

Reservoir sites and lakes shown upon plat furnished; sites in mountains, and not shown upon plat, and lakes now existing that could be enlarged and utilized.

RESERVOIR SITES AND LAKES (AS SHOWN UPON PLAT FURNISHED).

No.	Local name of sites.	Length.	Width.	Upon what stream located.	Remarks.
		Miles.	*Miles.*		
1	Baker's Cañon	1	⅛	Beaver	Outlet, narrow gorge in volcanic rock.
2	Beaver Cañon	¾	⅛	do	Do.
3	do	1	⅛	do	Outlet, abutting ridge and mountain.
4	Pole Creek	¾	1/10	North Creek	Do.
5	Lower Swamp	1	⅛	do	Do.
6	Wild Cat	½	⅛	Wild Cat	Do.
7	Indian Creek	1	⅛	Indian Creek	Outlet at end of wash from hills.
8	do	1½	½	do	Do.
9	Minersville	4	1	Beam	Outlet in one volcanic rock and abutting ridge.
10	Minersville Cañon	1	¼	do	Do.
11	Dupaix's Mill	1½	¼	do	Outlet between abutting ridge and hills.
12	Minersville Valley	1½	¼	do	Depression in the land.
13	do	1½	¼	do	Do.
14	do	1	⅛	do	Do.

RESERVOIR SITES IN MOUNTAINS (NOT SHOWN UPON PLAT).

1	Le Baron Meadows	2	⅛	Beam	Outlet, gorge in solid rock.
2	Britt's Meadows	2	⅛	do	Outlet at intersection of two ridges.
3	Kent's Lake	½	¼	do	Outlet, at Our Rock (a natural basin).
4	Kent's Adjacent	¼	¼	do	Do.
5	do	¼	¼	do	Do.
6	Matthews' Lake	⅛	⅛	do	Do.

EXISTING LAKES THAT COULD BE ENLARGED AND UTILIZED.

1	Puffer Lake	1½	⅛	Beam	Outlet, solid rock in gorge.
2	Blue Lake	⅛	⅛	North Creek	Do.
3	Twin Lakes	¼	⅛	Beaver	Quite deep and easily enlarged.
4	do	¼	⅛	do	Do.
5	Birch Creek Lake	¼	⅛	do	Occasionally dries up.
6	Kent's Lake	⅛	¼	do	Artificial and noted under reservoir sites

List of ditches and owners in Beaver County.

No. of ditch.	Name of one of the principal owners in each ditch.	Town.	Date of construction of ditch or canal.	Irrigated by each ditch.	Area under each ditch that could be irrigated with increase of water.	Days between each time of irrigating.	Hours to each 5 acres.	Remarks.
	BEAVER RIVER STREAM.			*Acres.*	*Acres.*			
1	F. Harris	Beaver	1885	80	320	14	24	
2	B. Bennett E. C. Mathews	do do	1879 1887	40 80	100 40	14 14	24 24	
3	City canal; Mayor of Beaver City.	do	1856	2,640	80	7 14	12 24	For city lots Farm lands.
4	W Allred	do	1869	20	40	14	24	
5	W. G. Nowers	do	1859	400	30	18	24	South field
6	G. E. Owen	do	1867	80	.....	16	24	
7	W Greenwood	do	1856	115	.....	18	24	
8	T. Parkinson	do	1857	105	30	16	24	
9	E. Patterson	do	1865	200	30	21	24	
10	J. Jones	Adamsville	1884	40	640	14	24	Adamsville bench.
11	W. Fotheringham	Beaver	1879	80	320	18	24	
12	H. Emerson	do	1879	60	200	18	24	
13	J. H. Josephs	Adamsville	1863	750	40	14	24	Town canal.
14	do	do	1866	330	.....	14	24	South side.
15	R. Griffiths	do	1868	200	.....	14	24	Hay ditch.
16	J. T. Josephs	do	1868	265	.....	18	24	
17	M. M. Shepherd	Beaver	1873	40	.....	18	24	Rocky ford.
18	J. H. Jones	Minersville	1876	80	40	18	24	
19	J. McKnight	do	1860	1,200	600	18	24	Minersville town canal.
20	W L. H. Dotson	do	1874	80	100	18	24	
21	W. Gilling	do	1875	70	100	18	24	
22	J. W. Christian	Beaun	1879	50	.....	14	24	
23	P. S. Martin	Milford	1887	100	200	18	24	
24	J. McGeary	Beam	1876	100	.....	.....	.....	Yellow banks; hay-lan watered in high water.
	SOUTH CREEK STREAM.							
1	O. Puffer	Beam	1879	75	80	16	24	
2	C. Merchant	do	1860	75	.....	16	24	
3	G. Hutchings	do	1879	80	80	16	24	
4	C. Warby	do	1882	160	40	16	24	
5	J. Warby	do	1871	40	40	16	24	
6	J. Lang, jr	do	1876	40	80	16	24	
7	T. Frayer	do	1885	60	80	16	24	
8	H. Gale	do	1866	100	160	16	24	
9	J. Gilles	do	1879	40	40	16	24	
10	E. Tolton	do	.....	.....	.....	16	24	
11	J. R. Murdock	do	1876	300	1,000	16	24	
12	C. Miller	Greenville	1861	224	40	16	24	
	SOUTH CREEK STREAM.							
1	W. J. Cox	Beam	1860	80	.....	18	24	
2	E. Tolton	do	1866	80	80	18	24	
3	G. Mumford	do	1866	150	40	18	24	
4	W. G. Nowers	do	1857	200	.....	18	24	
5	R. Patterson	do	1881	70	320	18	24	
	INDIAN CREEK.							
1	A. Tinktell	Beam	1872	200	300	18	24	
2	do	do	1859	105	40	18	24	
	WILD CAT.							
1	J. Farrer, jr	Beam	1875	160	200	18	24	
	PINE CREEK.							
1	A. Olsen	Beam	1865	50	400	.....	.....	

NOTES.

Area of water-shed of the Beaver Mountains, 180 square miles.

Altitude of Beaver Mountains, about 10,000 feet. First highest peak, 11,894 feet (Mount Belknap); second highest peak, 11,730 feet (Mount Baldy).

Depth of snow annually falling on Beaver Mountains, estimated depth not known, but by some placed at 8 feet, it falling from 4 feet to 20 feet in different sections.

AGRICULTURAL LANDS SURVEYED, OCCUPIED, AND UNOCCUPIED.

Beaver Valley.—Occupied (about), 7,500 acres, irrigated; 4,750 acres not irrigated; unoccupied, 97,280 acres, of which about 60 per cent. is available for agriculture, with storage of water. Altitude of Beaver Valley, 6,020 feet.

Minersville Valley.—Occupied (about), 2,000 acres, irrigated; 1,000 acres not irrigated; unoccupied, 131,328 acres, of which about 95 per cent. is available for agriculture, with storage and increase of water. Altitude of Minersville Valley, 5,090 feet.

Irrigating streams.—The cross-sectional area of an ordinary irrigating stream is about 26 inches wide by 5 inches in depth, or 130 inches face. Speed of such irrigating stream about 66 feet per minute, of which it is estimated to run about 80 per cent. of its computed volume (see Leffel's Water Works).

The irrigating season commences about May 15 and ends about August 15 of each year, crops of lucern, potatoes, orchards, and gardens being irrigated one month later.

REPORT ON BOX ELDER COUNTY.

The southeastern part of Box Elder County embraces about 3,600 acres of land under cultivation, of which about 10 per cent. constitutes made or natural meadow. About 2,100 acres of this section is under irrigation, of which, however, but a small portion has sufficient water to produce a good agricultural crop in dry seasons. The water supply, with the exception of a few minor springs claimed by private parties, is obtained from Willard and Three Mile creeks.

Willard Creek, so far as ascertained, furnishes no favorable location for reservoirs, the fall being too great, but experience has proved that about one-third the amount of water could be saved if the bed of the creek was walled up with rocks.

Three Mile Creek has an excellent location for a reservoir at the head of the creek. Here is found a basin with a swampy bottom and containing several minor springs, the whole surrounded by mountains. A dam at the outlet of this basin, 260 feet long, 20 feet high at the bed of the creek, would inclose over 3,000,000 cubic feet of water, sufficient to irrigate 700 acres of land. Cost of dam, $800.

Summary.—Cultivated land in this section, 3,600 acres; irrigated land in this section, 2,100 acres; meadow, 360 acres; proposed reservoir dam site, cost, $800; area subject to cultivation if supplied with water, 2,500 acres.

Willard Creek is owned and controlled by the city. Three Mile Creek is claimed by adjoining settlers. Elevation of agricultural land, 4,230 to 4,400 feet above sea; elevation of head of Willard Creek, 9,200 feet; elevation of Three Mile Creek, 6,300 feet.

The section in which Brigham City, the county seat, is located has an area of nearly 9,600 acres of cultivated land, of which about 5,100 acres are under irrigation. About 1,900 acres are in meadow. Quantity of water insufficient for industrial use.

Reservoir.—East of Brigham City, in what has acquired the local name of "Devil's Gate Valley," owing to the rough inlet at the head, and much above Box Elder Creek, is a good reservoir site. A dam at the contracted place shown by the map, 300 feet long, 50 feet high at the bed of the creek, would inclose over 15,000,000 cubic feet of water, sufficient to water 3,000 acres of land. The water is so far unclaimed, as it ceases to connect with Box Elder Creek during the summer.

Summary.—One reservoir site (proposed dam) cost, $4,000; cultivated land in this section, 9,600 acres; irrigated land in this section, 5,100 acres; meadow, 1,900.

Box Elder Creek owned by Brigham City; creeks at Honeyville owned by that town and farmers; elevation of agricultural land, lower belt, 4,250 to 4,500; Mantua or higher valley, 5,168 feet; reservoir in Devil's Gate Valley, 6,100 feet above the sea; soil subject to irrigation if supplied with water, 15,000 acres.

The next section embraces nearly 12,000 acres of cultivated soil, of which about 1,900 acres are irrigated.

Beaver Creek, in the northeast of the section, has one fine reservoir site (dimensions and location not reported), of which that country is greatly in need. Cost, $600.

The springs on section 29, township 11, are composed of hot and cold, salt and fresh water, respectively. These are separated by a dam and the cold and fresh water *conveyed to* Honeyville town for irrigation in a canal 1¾ miles long, 4 feet wide, and *2 feet deep, at a fall of* 1½ feet to the mile.

The additional area that could be irrigated in this section if water could be provided is not far from 19,000 acres.

Salt Spring on section 6, township 11 north, range 3 west, is of a brackish nature. The consequence is that it is nearly abandoned for irrigation except on alfalfa, to which it seems to be less injurious. The same note will apply with full force on the waters of Malad River.

Summary.—Cultivated, 12,000 acres; irrigated, 1,900 acres; subject to irrigation if water provided, 19,000 acres; reservoir site (proposed),1; elevation of farms, 4,280 to 4,500 feet above sea.

The upper section of county contains about 6,000 acres of cultivated soil without water. No site for reservoir is reported. Elevation of farms are from 4,420 to 4,540 feet; subject to irrigation if water is supplied, 600 acres.

A dam is proposed across Bear River with a canal from there. Surveys have been made for a dam 250 feet long and 20 feet high across the river; a tunnel 14 by 10 feet for 1½ miles out and in through the cliffs, with a fall of 4 feet per mile, and then a canal 70 feet wide and 6 feet deep, fall 1 foot per mile. About one-half mile below the dam it is proposed to flume part of the water across the river into a canal on the west side of the river. On the west side of the river the canal is surveyed for a distance of 45 miles, and on the east side it crosses the boundary line into Weber County, at a distance of about 43 miles.

The Malad River section shows 3,000 acres of cultivated soil. Canals and ditches were built as early as 1868 and the water taken out of Malade River by aid of a dam. The water being of a brackish character proved injurious to the vegetation and the irrigation abandoned, except on alfalfa to a limited extent. About 22,000 acres additional could be cultivated if water was applied.

About 14 miles of canals were constructed. The main canal 4 miles long, 12 feet wide, 2 feet deep, and 1½-foot fall per mile.

There are 80 acres of dry farm at Blind Spring on section 10, township 12 north, range 4 west, and 1,000 acres cultivated in Blue Spring Valley, of which 150 acres are irrigated.

The canals are two in number and 2½ miles in length, 3 to 4 feet wide at bottom, and falls 4 feet per mile. The owner is Promontory Stock Ranch Company, Promontory, Utah.

NOTE.—The canals take all the water and no chance for reservoirs is reported.

About 2,000 acres additional could be irrigated if water is supplied. Elevation is about 4,700 feet above sea-level.

The Portage section represents about 7,000 acres of land under culture, of which 2,500 acres are irrigated for grain or hay.

The main water supply is Malad River through Portage Ditch, 10 feet wide, 2 feet deep, 7 miles long, and falls 1½ feet per mile. The water in said river is good at this point, the bad water running in from some mineral spring below.

Portage Creek supplies Portage town. This creek has a fine site for a reservoir. The settlers had begun construction, but it was abandoned for want of means. Its estimated dimensions are: Length, 600 feet; height, 20 feet; contents, 15,000 cubic yards; capacity, 20,000,000 to 25,000,000 cubic feet of water; $40,000 cost.

This section also has been a thriving Indian settlement, with many houses and good farms. The water supply is inadequate.

Summary.—Cultivated land, 7,000 acres; irrigated land, 2,500 acres; reservoir site (proposed), 1; arable land if water supplied, 3,000 acres; elevation of farms, 4,500 feet to 4,600 feet above sea; elevation of reservoir, 5,000 feet above sea.

Two other sections show, one a cultivated area of nearly 4,000 acres, of which 2,000 acres are under irrigation. There are two chances for reservoirs, but locations and dimensions are not reported. Water supply insufficient. Elevation of farms 5,640 to 5,675 feet above the sea. In meadow, 150 acres.

The other represents a cultivated area of nearly 1,500 acres, including 250 acres in meadow. About 950 acres are irrigated. Nearly 11 miles of canals have been built. Width, 4 feet; depth, 2 feet; fall, 3 feet per mile. Elevation of valley 4,600 to 4,625 feet above sea. Water supply insufficient. Facilities for reservoirs good, but no report made on locations and dimensions. Additional arable land if supplied with water, 2,500 acres.

The most northerly section of country is one that has been very hard for the settlers to subdue, owing to the sterility of the nature.

The area cultivated is nearly 2,500 acres; the area irrigated, 1,400 acres. Elevation of valley, 4,275 feet above the sea. Water supply from Deep Creek in Idaho. Canals 1.5 miles long, 10 feet wide, 2 feet deep, and 2-foot fall per mile.

Water supply insufficient. Facilities for reservoirs good. Cost and dimensions not given. Facilities for raising 50,000 bushels and homes for one hundred families additional is reported if water was supplied. Additional arable land 9,600 acres.

SUMMARY OF PRECEDING DATA.

	Acres.
Total area cultivated	50,280
Additional not reported	3,000
Grand total	53,280
Total area irrigated	16,100
Total area not reported	1,200
Grand total	17,300
Meadow	2,910
Meadow not reported	300
Grand total	3,210
Arable land not cultivated	76,200
Arable land not reported	4,000
Grand total	80,200

N. P. ANDERSON,
County Surveyor.

REPORT ON CACHE COUNTY.

Streams.	Streams from which water is diverted.	Acres irrigated.	Acres cultivated.	Good land that could be irrigated by increasing water supply.	Land that could be irrigated by new canals.	Flow of water per second.	Length of canal.
				Acres.	*Acres.*	*Cub. ft.*	*Miles.*
Logan, Hyde Park and Smithfield Canal.	Logan River	1,200	1,200	2,500	.....	39	10
Logan and Richmond Canal	do	3,000	4,000	.....	.....	68	8
Logan and Hyde Park Canal	do	2,200	2,200	.....	.....	35	6
Logan and Benson Canal	do	2,800	2,800	.....	1,500	38	7
Providence Canal No. 1	Blacksmith Fork						
Providence Canal No. 2	do						
Providence Canal No. 6	Providence Cañon	1,090	2,400	.....	500	.....	.....
Providence Canal No. 7	Logan River						
Millville Canal No. 1	Blacksmith Fork and Clear Creek.	2,400	2,400	.....	.....	.....	7
Millville Canal No. 2	do	300	3,000	500	300	.....	.....
Millville Canal No. 3	do	.....	.....	.....	.....	.....	.....
Millville Canal No. 4	do	.....	.....	.....	.....	.....	.....
Blacksmith Fork Canal	Blacksmith Fork	2,500	2,500	2,720	2,720	.....	5½
Paradise Canal	Little Bear River	2,300	2,300	.....	.....	.....	9
Wellsville South Irrigation Canal	do	600	600	.....	.....	.....	9
Claton Canal	Claton Spring	176	176	.....	.....	.....	1½
City Creek Canal	8 per cent. Springs	257	257	.....	1,000	.....	1½
Deep Cañon Creek Canal	Deep Canny Creek	199	199	.....	.....	.....	2
Gardner Ditch	Gardner Spring	290	290	.....	.....	.....	4
Benson and Logan Canal	Logan River	1,000	1,000	.....	1,000	.....	3½
Newton Canal	Newton Reservoir	1,000	1,000	2,500	18,000	.....	2
Newton Reservoir Canal	do	1,000	1,000	.....	.....	.....	2
Birch Creek Canal	Birch Creek	375	375	1,800	2,000	.....	3½
Upper Dam Ditch	Clarkston Creek	200	200	.....	.....	.....	3
Lower Dam Ditch	do	225	225	.....	.....	.....	4
City Creek Canal	City Creek	285	285	.....	.....	.....	4
Trenton Canal	Weston Creek	.....	.....	5,000	10,000	.....	.....
Cubb River Irrigating Canal	Cubb River	6,000	6,000	6,000	.....	.....	12
Coveville Lower and Upper Canal	Cubb River and High Creek.	1,497	1,497	3,449	.....	.....	.....
Richmond Canal	High Creek and Cherry Creek.	2,500	2,500	3,000	3,000	.....	6
Smithfield irrigating district	Summit and Birch Creek.	2,970	2,970	1,000	1,160	.....	.....
Logan River		.....	.....	.....	.....	.....	188.50
East Fork of Little Bear River		.....	.....	.....	.....	.....	18.06
South Fork of Little Bear River		.....	.....	.....	.....	.....	24
Blacksmith Fork River		.....	.....	.....	.....	.....	137.42
Smithfield Creek		.....	.....	.....	.....	.....	*35
High Creek		.....	.....	.....	.....	.....	*25
Lewiston Canal		.....	.....	.....	.....	.....	12.15
West Branch of Lewiston Canal		.....	.....	.....	.....	.....	4
Paradise Irrigating Canal	E. and S. Forks Little Bear River	1,780	1,780	2,204	2,100	.....	.....
Total		41,444	43,154	30,173	43,280	.....	.....

*Approximately.

NOTES.—Average depth of snow in mountains during winter, 3 feet.

Irrigation season begins about May 1, and ends about the 1st of September.

The elevation of Cache Valley is 4,533 feet.

About 33 per cent. of the crops of this county have been lost this year from lack of water.

Land is irrigated at intervals of about two weeks when water supply is plentiful and about four hours, time is allowed for watering 1 acre of land.

There are many places in the mountains where water can be stored.

REPORT ON CACHE COUNTY.

Width of bottom.	Fall per mile.	Cost of canal.	When constructed.	Claim to water.	By whom owned.	Shares into which ownership is divided.	Shares issued.	Par value of each share.	Actual selling value per share.	Annual tax or assessment per share per acre.	Arable land under canal.	Actually watered.
Feet.	*Feet.*									*Cents.*	*Acres.*	*Acres.*
12	4	$50,000	1883	Fifth..	Corp'n....	4,000	2,000	100%	100%	25	3,700	1,200
12	7	30,000	1865–'6	Fourth	Ass'n.....	.....	.....	.....	.....	25	4,000	3,000
12	7	18,000	1860	First..	....do.....	.....	.....	.....	.....	10	2,200	2,200
12	6	15,000	1861	Second	....do.....	.....	.....	.....	.....	10	2,800	2,800
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2,900	1,690
6	.....	8,000	1865	First..	Ass'n.....	.....	.....	.....	.....	80	2,400	2,400
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	3,500	3,000
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
8	13	5,500	1860	First..	Ass'n.....	1,000	1,100	$5.00	$5.00	35	2,500	2,500
8	15	5,075	1867	...do..	....do.....	1,015	1,015	$5.00	15.00	60	5,000	2,300
8	.....	9,000	1886	Third	....do.....	.....	.....	50.00	50.00	.....	600	600
3	1	500	1860	First..	....do.....	.....	.....	.....	.....	25	350	176
2	50	400	1858	.. do ..	City cor...	.....	.....	.....	.....	40	2,000	257
3	50	100	1859	...do..	....do.....	.....	.....	.....	.....	40	1,000	199
4	1	6,000	1860	...do..	Ass'n.....	.....	.....	.....	.....	.....	2,000	290
10	4	4,500	1880	Second	....do.....	.....	.....	.....	.....	25	1,800	1,000
8	6	.....	.....	.....	....do.....	.....	.....	.....	.....	.....	14,000	1,000
8	6	7,000	1871	.....	....do.....	280	280	25.00	.....	10%	3,200	1,000
2½	.....	1,500	1866	First..	....do.....	.....	.....	.....	.....	20	1,800	375
2	.....	750	1866	...do..	....do.....	.....	.....	.....	.....	25	200	200
2½	.....	1,000	1866	...do..	....do.....	.....	.....	.....	.....	20	225	225
2½	.....	1,200	1869	...do..	....do.....	.....	.....	.....	.....	45	285	285
.....	.....	.....	1869	.....	....do.....	.....	.....	.....	.....	.....	.....	.....
16	.....	52,000	1876	First..	.....	1,040	1,040	50.00	....	3%	1,200	6,000
.....	.....	.....	1860	.....	Ass'n.....	.....	.....	.....	.....	.....	3,449	1,497
8	2	.....	1860	First..	City	.....	.....	.....	.....	20	5,500	2,500
.....	.....	.....	1860	.....	.....	.....	.....	.....	.....	.....	.....	2,970
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	1867–'68	.....	.....	.....	.....	.....	.....	.....	.....	1,780
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	77,409	41,444

REPORT ON EMERY COUNTY.

Snow falls from 1 to 6 feet in our mountains.

Irrigation season commences in May, and ends the latter part of October.

A stream of 6 cubic inches will water 1 acre of sandy soil in twenty-four hours. Four waterings will mature small grain, beets and carrots. Three for potatoes.

A stream of 6 cubic inches will water 1 acre of clayey soil in twenty-four hours. Will take six waterings to mature crops.

The number of acres lost to cultivation this year from lack of water will reach 25 per cent. of total arable.

There are many small streams taken out of the creeks that are not listed.

Our ditches were built between 1879 and 1885.

Area irrigated—14,825 acres.

Area that can be irrigated by present ditches—29,200 acres.

Area that could be reclaimed if water was obtainable—372,620 acres.

There are two good reservoir sites on the head of Muddy Creek. Estimated capacity, 25,000,000 cubic feet. Two on head of Ferron Creek; there is a vast flat. Joe's Valley, or a part of said valley, could be turned into or used as a reservoir. It would cover two or three sections, with a mean depth of 15 cubic feet. Several suitable sites are found at or near Moab and Blake Creeks. Six or eight sites also at Lower Crossing, near Price River, in the mountains, with an average extent of fifteen acres each.

The irrigation seasons are—March 15 to November 1 in Castle Valley; March 1 to November 1, Little and Big Grand Valleys.

The supply in Castle Valley is about 4,500 feet; Little and Big Grand, 3,900 feet; Cottonwood, about 1,800; Ferron, about 1,625; Muddy, about 1,450; Huntington, about 1,750; Price about 1,600.

Green and Grande are both large rivers.

The duty of water is about 4 miner's inches for sandy soil, 3½ miner's inches for clayey soil.

Water is turned on every twelve or fourteen days, fifteen to twenty-four hours at a time.

On the tributaries of Price River there are many available natural reservoir sites. It is not possible to now approximate size or cost of construction. It is believed, however, that if four reservoirs were constructed, one on each of the following-named tributaries: Wilson Creek, Horse Creek, Gooseberry Creek, and Gordon Creek, that a cient amount of water would be stored to irrigate all lands in Castle Valley north of line of township 17 south—in all, about 150,000 acres. The sites for said reservoirs are natural sites, and reservoirs could be constructed very cheaply; for instance, at the head of Gordon Creek, a dam constructed across the cañon, below "Miller Ranch," 200 feet in length and 75 feet in height, would create a lake 2 miles square; there being an abundance of rock on the ground suitable for use in constructing said reservoir.

List of canals in Emery County.

Name of ditch.	Sources of support.	Name of town, trustees, or owners.
Clipper Canal (increase)	Cottonwood Creek	A. C. Van Buren, president, Orangeville.
Blue Cut Canal (inc.)	do	N. P. Miller, president, Castle Dale.
Castle Dale, Town Ditch	do	Jens Nelson, president, Castle Dale.
Jeffs' Ditch	do	James, Ephraim and Emma Jeffs and C. G. Larson, Castle Dale.
Wilcox Ditch	do	James H. Wilcox, owner.
Upper South Ditch	Ferron Creek	William Taylor, president, Ferron.
Town Ditch	do	Do.
King Ditch	do	Do.
Molen Ditch	do	Do.
Peterson Ditch (inc.)	do	Do.
Lower South Ditch	do	Do.
Casper Christensen Ditch	Muddy Creek	Casper Christensen, Emery.
Muddy Canal (inc.)	do	P. V. Bundersen, president, Emery.
Pioneer Ditch No. 1	Price River	
Pioneer Ditch No. 2	do	F. E. Grauns, Emery.
Price Water Ditch	do	George Fraoulson, Emery.
Wellington Canal	do	Watter Barney, Emery.
Robert Snider Ditch	do	Robert Snider, Emery.
R. M. Watson's Ditch	Coal Creek	R. M. Wateo , Emery.
R. R. Hutchinson Canal	Price River	R. R. Hutchinson, Emery.
Smith Ditch	Huntington Creek	Chris Johnson, Huntington.
Hill Ditch	do	Do.
Brockbank Ditch	do	Do.

Lists of canals in Emery County—Continued.

Name of ditch.	Sources of support.	Name of town, trustees, or owners.
Jensen Ditch	Huntington Creek	Chris. Johnson, Huntington.
McHadden and Cleveland Canal	do	Do.
Huntington Canal	do	Do.
North Ditch, Day Upper	do	Do.
Crandal, Day Lower	do	Do.
Wakefield, East Bend (inc.)	do	Do.
Avery Powell	do	Do.
Humble	do	Do.
Green River Canal	Green River	J. T. Farrer, president, Blake.
Pack and Mill Creek Canals	do	George H. Wade, water-master, Moab.

REPORT ON GARFIELD COUNTY.

The facilities for reservoiring at head waters of Sevier River are almost unlimited; large basins, deep and with small outlets, and deep snows in winter; the majority of these basins drain large areas.

There are no facilities for storage in Henrieville, Cannonville, or Coyote, but in Escalante there are a number of small lakes which can be tapped and improved to more than double their acreage. The citizens have initiated a movement to bring a creek across a mountain to increase their water supply.

A pond in township 35, sections 7, 8, 17, 18, is a natural basin with a drainage of 10 square miles, with one opening into creek leading to Panguitch Lake. This opening is in basaltic rock, very narrow, say 3 or 4 rods wide, with material in abundance, quarried by nature, to make a dam. It furnishes for two months a large stream of water from snow; will make a reservoir 6 square miles.

Panguitch Lake is located at township 35, sections 33 and 34, and township 36, sections 43 and 3. This is a natural reservoir and can be made to hold 5 square miles of water at a very moderate cost. The citizens of Panguitch have raised this lake 6 feet, at a cost of $3,000, including land purchases.

Blen Springs Valley could be made to contain 2 square miles of water at a moderate cost; land would cost more than dam.

The right-hand fork of Mammoth Creek could be diverted for eight months of each year (by making a cut 2 miles long) and become a feeder of Panguitch Lake; it would afford five or six streams for irrigating.

Table of ditches, etc., in Garfield County.

NO. I.

No. of ditch.	Name of owner.	Date of completion.	Amount irrigated.	Source of water.
			Acres.	
1	James B. Thompson	July 29, 1884	45	East Fork Pahreah.
2	Willis A. Thompson	....do	21	Do.
3	Joseph E. Thompson	....do	26	Do.
4	John F. Pollock	....do	21	Do.
5	E. Littlefield	....do	21	Do.
6	Daniel Goulding	....do	23	Do.
7	John Goulding	....do	21	Do.
8	John O. Thompson, sr	....do	34	Do.
9	Morrison Meacham	....do	21	Do.
10	Lucy D. Thompson	....do	13	Do.
11	Abraham A. Stevens	....do	21	Do.
12	Wm. W. Pollock	....do	21	Do.
13	Joseph Ingram	....do	43	Do.
14	Samuel Littlefield	....do	21	Do.
15	Joseph G. Goulding	....do	21	Do.
16	William S. Thompson	....do	32	Do.
17	Samuel Meacham	....do	21	Do.
18	Cannonville Co	....do	.....	Pine Creek.
19	Cannonville Co	....do	3¼	East Fork Sevier.
20	Edward Wilcox	....do	20	North and Birch Creek.
21	Henry J. White	....do	20	Butler Farm Creek.
22	Kanana Stock Co	....do	1½	East Fork Sevier.
23	Cyrus Hencock	....do	.....	Lime Kiln Wash.
24	Albert De Long	....do	.....	Do.
25	Mathew McEwen	....do	.....	Do.
26	Wm. D. Leflere	....do	.....	Do.
27	Welham Lewman	.....	.....	Do.
28	O. S. Hatch	.....	.....	Do.
29	Henry J. White	Mar. 2, 1885	20	North Creek.
30	Owner not named	.....	.....	
31	J. W. Crosby	.....	.....	
32	Owner not named	.....	.....	
33	Edward Allan	June 2, 1885	.....	Poison Creek.
34	Church A. Bros.	.....	.....	
35	Haden W. Church	.....	.....	
36	Aaron Assay	.....	.....	
60	Albert De Long	June 7, 1887	118	Sevier.
61	Meltiah Hatch	....do	320	Sevier River.
62	Neils P. Clove	July 9, 1887	200	Mammoth and Sevier.
63	Watkins, Reese & Co	June 4, 1888	640	Horse Creek.
64	John L. Levy	Mar. 4, 1889	40	East Fork.
66	Thomas F. Langford	June 7, 1889	640	Do.

NOTE.—There is in addition from twenty to thirty independent ditches for isolated farms and ranches, with a capacity of from 40 to 160 acres.

No. II.

No. of ditch.	Name of owner.	Date of completion.	Service of water per hour.	Source of supply.
			Hours.	
39	Wm. J. Henderson	Sept. 7, 1885	25	West Fork Pahreah.
40	J. Jones	....do	22½	Do.
41	K. A. Fletcher	....do	23½	Do.
42	D. O. Littlefield	....do	36	Do.
43	Owner not named			
44	O. Christian	....do	21½	Do.
45	J. Clark	....do	21½	Do.
46	Mary Porter	....do	16½	Do.
47	E. H. Thompson	Sept. 8, 1885	14½	Do.
48	O. Anderson	....do	12½	Do.
49	O. Hatch	....do	1½	Do.
50	S. M. Meacham	....do	2½	Do.
51	Lucy Littlefield	....do	1½	Do.
52	Zion Co-operative	Sept. 7, 1885	1½	Do.
53	Relief Society	Sept. 9, 1885	1½	Do.
54	E. Pearce	....do	1½	Do.
55	H. Barney	....do	1½	Do.
56	Wm. Lewman	Sept. 8, 1885	1½	Do.
57	A. Workman	....do	1½	Do.
58	John Goulding	July 2, 1885	(*)	Do.
59	James Wiley & Co	Mar. 1, 1886		All of Lost Creek.
65	Hyrum Williams	June 7, 1886	864 inches	for 320 acres.

* One-third seepage.

REPORT ON MORGAN COUNTY.

This county is situated principally on the Weber River, bounded east by Summit County, south by Salt Lake County, west by Davis, and north by Weber County.

The railway elevation passing through Morgan City is 5,080 feet above the sea-level. There are about 10,000 acres of arable and meadow land in the county. Our water supply is usually abundant, this being the first year we have suffered to any extent for twenty-five years.

There are twenty-seven corporate and company ditches, and nineteen private or individual water ditches. The water is supplied from ten creeks and one river.

The approximate estimate of the flow of water into our county has never been made. The surplus water from the creeks empty into the Weber River, which flows through the heart of our county into Weber and Davis Counties.

Our probable loss of crops this year will amount to 1,000 acres. The west part of the county, supplied from small creeks, has been the principal sufferer this season.

There is one good site for a reservoir in Lime Creek Cañon (immediately west of Milton), where a reservoir of 10 acres of water, averaging 10 feet deep, could be made for a small expense. Another good site for a reservoir exists in Deep Creek Cañon, where a reservoir of the same size and depth as above stated could be constructed. East Cañon furnishes a most magnificent site for a large reservoir, at a place known as the "Denês Fate" situated about 4 miles east of Porterville at the head of the valley. Ledges of rocks descend on each side to the bed of Cañon Creek, leaving a gate about 20 feet wide for the passage of the stream. A wall of rocks rises almost perpendicularly for 60 feet. By putting in a strong dam here the water would back the stream 2 miles, covering an area of 640 acres of an average depth of 20 feet.

The average depth of snow-fall in our mountains is 5 feet.

The amount of water to irrigate an acre of land varies according to soil, gravelly soil taking as much again as clay soil; 1 cubic foot per second for 100 acres is an approximate estimate.

Irrigation commences about the 20th of May and terminates about the 1st of September. Small grain is mostly irrigated in the months of June and July. Grain and alfalfa are watered about every twenty days on clay soils, and about every ten days on gravelly soil; gardens every ten days. Two waterings are sufficient on most soils in our county to mature small grain.

Companies and corporations have not claimed the water as such companies. All the water claims have been claimed by individuals and recorded to them. It would make this report too lengthy to make an abstract of all such claims. The accompanying list of companies, ditches, etc., will show the nature and extent of water rights.

S. FRANCIS,
JOS. R. PORTER,
County Commissioners.

Corporate and association ditches of Morgan County.

Number.	Name of canal or ditch.	Names of owners and post-office address.	When built.	Streams from which the water is diverted.	Acres irrigated.	Acres that may be irrigated if there was more water.	Acres that could be irrigated by the construction of new ditches.	Length of canal or ditch.	First cost of construction.	Nature of right.
								Miles.		
1	South Mill Creek	J. Durant *et al.*, Morgan	1865	Mill Creek	150	50	.....	2	$400	First.
2	Round Valley Spring Ditch and Weber River Ditch.	E. W. Hunter *et al.*, Morgan	1864	Weber River and Spring	290	70	.....	5½	750	Do.
3	West Porterville Ditch	H. Florence *et al.*, Morgan	1866	Mill Creek	500	50	.....	4½	1,000	Do.
4	Richville Mill Race Ditch	Herman & Taggart, Morgan	1862	Cañon Creek	330	.....	.....	3	900	Do.
5	East Porterville Ditch	John P. Porter, sr., *et al.*, Morgan.	1862	do	312	70	.....	3½	1,480	Do.
6	East Richville Upper and Lower Ditches.	Mels Peterson *et al.*, Morgan	1862	do	450	50	.....	7	1,600	Do.
7	Gordon Creek Ditch Company	John A. Waite *et al.*, Peterson.	1858	Gordon Creek	200	58	.....	3¼	300	Do.
8	Cottonwood Creek Ditch Company	Buck Miller *et al.*, Peterson	1869	Cottonwood Creek	200	.....	.....	4	1,000	Do.
9	Peterson Creek Ditch Company	Peterson	1855	Peterson Creek	200	.....	.....	1¾	320	Do.
10	Dalton Creek Ditch Company	do	1862	Dalton Creek	150	.....	.....	1¾	150	Do.
11	Line Creek Irrigation Company	Morgan	1861	Line Creek	350	.....	.....	6	1,400	Do.
12	South Round Valley Irrigation Co.	do	1864	Weber River	120	60	70	3½	720	Do.
13	North Morgan Irrigation Company	do	1864	do	428	.....	.....	4	1,000	Do.
14	North Morgan Mill Race Irrigation Co.	do	1861	do	300	100	.....	2	250	Do.
15	North and South Spring Irrigation Co.	do	1862	Morgan City Springs	37	40	.....	1	50	Do.
16	Weber Canal Irrigation Company	do	1864	Weber River	400	.....	.....	3	6,000	Do.
17	Morgan City Irrigation Company	do	1861	do	360	.....	.....	4	3,800	Do.
18	Littleton and Milton Cañon Creek Irrigation Company.	do	1888	Cañon Creek	200	.....	200	3	200	Second.
19	Deep Creek Irrigation Company	do	1861	Deep Creek	400	400	.....	4	850	First.
20	Enterprise Bottom Irrigation Co.	Peterson	.....	Stodart Springs	250	125	.....	4	1,500	Do.
21	Spring Hollow Ditch Company	do	1867	Spring Hollow Springs	75	25	.....	3	200	Do.
22	Enterprise Bench Irrigation Company	do	1889	Weber River	200	.....	.....	7	5,000	Second.
23	Loss Creek Irrigation Company	Croydon	1864	Loss Creek	350	.....	.....	2	1,200	First.
24	Croydon Upper Ditch Irrigation Co	do	1869	do	70	10	.....	3	1,000	Do.
25	Littleton Cañon Creek Irrigation Co.	Morgan	1880	Cañon Creek	240	100	.....	4	600	Second.
26	Eleven private ditches	Croydon	1880	Loss Creek	380	200	.....	10	2,000	First and second.
27	Eight private ditches	Morgan	1858–69	Weber River	300	.....	.....	5	800	Do.
	Total				7,240	1,408	270	109	$34,470	

REPORT ON RICH COUNTY.

According to Monteith's Geography, Bear River Valley is 6,422 feet above the level of the sea. The snow-fall in the mountains adjoining said valley on the south and west is about 5 feet. That is, it becomes about that deep at a time during the winter, taking no account of what melts before the general spring thaw. There was much less snow than that last winter in said mountains.

According to said geography Bear Lake Valley is 6,001 feet above sea level. The snow-fall during the winter in the mountains encircling said valley is usually about 6 feet, but it was much less than that last winter.

Irrigation begins in Bear Lake Valley about the 1st of April and ends about the 15th of September, the latter date being for the last crop of lucern. For grain and vegetables irrigation begins from about the 1st of May to the 1st of June and ends about the middle of August, varying somewhat according to the season and weather. But it has been found beneficial after crops have been gathered to turn water on the land and let it run all winter, thereby moistening up the ground for next season's crop; therefore the irrigation season may practically be considered to continue the year through, except while drying the land enough for gathering crops, plowing, etc.

In Bear River Valley irrigation begins properly about the 1st of April and ends about the 1st of August. But as the main crop of that valley is grass for hay, what water there is in the fall and winter is turned on to the land to prevent the latter from becoming too dry and cracking during hard freezing weather.

At to the quantity of water needed to mature an acre of any given crop, so much depends upon circumstances (season, land, and weather) that it is difficult to lay down any rule in relation to it. In Randolph precinct it has been estimated this summer that a stream, 2 feet 8 inches wide and 4 inches deep, with a velocity of 9¼ seconds to the rod, will only irrigate 60 acres of grain during the irrigation season of three months for that crop. That seems to me to be rather a low estimate; yet it was made on the ground when an irrigator was at work, the soil heavy and clayey, the sun hot, and the weather dry. In Laketown precinct an irrigation stream is made to do much more than that, with the same crop up to nearly or quite twice as much.

Regarding the time required at each irrigation to properly moisten the soil much depends upon the kind and dryness of the land and the distance down to moisture. Water running a few minutes over sandy, loamy, and some gravelly soils will often be sufficient to properly soak the land and moisten the crop; whereas heavy, clayey land, very dry, may require several hours, and then dry out much quicker than the former. Land should be irrigated about once a week for gardens and from fourteen to twenty-five days for general crops according to the weather, kind of soil, whether naturally moist, dry, or heavy, etc.

As to the quantity of water needed to irrigate the various kinds of mineral soils much depends upon the natural character of the land aside from the mineral it contains. If sandy or loamy, much less water will be required than if heavy or clayey. When the land slopes sufficiently to admit of water running off freely the latter can be used very advantageously in washing off the mineral. In fact it seems that there is no land, however strongly impregnated with salt or any other mineral, but can be reclaimed by fresh water running over it long enough.

The loss of crops in this county this season for lack of water for irrigation while considerable is nevertheless difficult to estimate in acres or in any other definite way. Anticipating a dry season, the farmers of Laketown precinct did not put in so much grain last spring as usual, yet over 100 acres of that crop has been lost and about 95 per cent. of the last crop of lucern also. About the same quantity of grain has been lost in Meadowville precinct, and probably about one-third of the hay crop there. Garden City, the remaining precinct of this county in Bear Lake Valley, has had plenty of water for irrigation, therefore no loss has been experienced there on account of drought. In Beaver River Valley the loss on the hay crop (the principal crop raised there) has been about one-half on account of the water failing so materially about the 1st of June. Bear River usually furnishes, at the beginning of the irrigation season, about five hundred irrigation streams, yet about the 1st of July it ceased to flow where it enters this county.

There are sites for reservations in this county to store up all the waste water during the spring thaws, which would about double its volume during the irrigation season. This, during seasons like the present, would probably irrigate about half the lands having claims on water for irrigation, and in years of ordinary snow-fall, would perhaps water a trifle more than said lands. Water rights for irrigation in this county are recognized by date of appropriation and use, not by date of record.

But little if anything can be done in this county towards storing water to irrigate land not already covered by the canals and ditches now constructed. As all that could be stored would hardly be sufficient, such a season as the present one, to irrigate more than one-half the lands having water rights, and in the favorable seasons not water much if *any more than said land*, the matter of storage seems to be all impor-

tant. But most of the landholders are hardly able to bear the expense of costly reservoirs. Does the Government contemplate assisting such? Would there be anything more than simple justice in such an act? The farmer or rancher has to pay just as much for his land in the arid region as those in more favored localities as regards moisture or the dews of heaven, and then go to the expense of from $3 to $10 per acre to irrigate it, and often is unable to do it properly at that. Certainly a little equalization would be in order towards encouraging the tiller of the soil in a region denied to quite a degree one of nature's main blessings. The pioneer work of settling the arid region has supplied an important link in the great national chain, a link in the absence of which would have been a broad expanse of dreary waste. Therefore the sturdy manhood that led or took part in the useful work deserves more recognition and encouragement at the hands of our national Government than has as yet been bestowed. Not, perhaps, because of any desire of the officers of the Government to be unappreciative of the efforts of any of its citizens towards advancing the interests of our common country, but because of not fully understanding what has been done and the circumstances under which it has been accomplished.

The characteristic fairness of the American people would, I think, prompt all, learning by experience what it is to settle an arid region and cause it to become fruitful, to cheerfully support the Government in dealing generously with the agriculturist in the dry belt. But in view of past experience in this respect quite a number of intelligent citizens of an adjoining Territory fear that the present move of the Government is quite as likely as otherwise to operate prejudicially to the interests of the present settlers, either by making it more difficult for them to construct reservoirs on the public domain, or of acquiring sites for reservoirs, or by Government building reservoirs and selling stored water from land now needing it.

To prove that Government designs to foster the interests of the unfortunate husbandman struggling with drought and low prices for farm products and beef, I would suggest the sinking of a few experimental artesian wells in Bear River Valley and in Bear Lake Valley, and building a storage reservoir in each of said valleys where such is most needed, or likely do the most good, and let the settlers have the benefits resulting therefrom free of cost.

The Narrows on Bear River near the Utah and Wyoming line is an excellent place to try the reservoir experiment, provided, of course, Messrs. Bothwell & Co. do not object and prevent the Government taking such a step on the public domain.

As regards Bear Lake, I would suggest that the Government make it a reservoir site, much as I suppose has been done with Utah Lake, under such rules and restrictions as will properly guard the interests of all concerned.

If any surplus water of Bear River or any other stream comes where it can be stored in Bear Lake and utilized to nobody's harm instead of going to waste all right. But no individual or company, certainly, should be allowed to strip, as it were, a portion of the little remaining moisture, or sap out of the Bear Lake or Bear River regions and try to take it to some distant point already liberally supplied in comparison with either of said regions with its natural share of water.

The citizens of this region can not but view with apprehension anything likely to lead to drawing the little remaining moisture out of or from their land and to start it to some far away place, much to be wasted in evaporation, etc.

Bear Lake can well be kept up to high-water mark most of the year, but it should never be drained below low-water mark, as the land along or near its shores not only would be dried out thereby, but the drying up of the wide belt of sand and mud around the present outer edge of the lake that would then be left bare to a hot August sun would be likely to produce malarial fevers and possibly other diseases.

The newspapers make Mr. Bothwell say, if I mistake not, that he has filed on Bear Lake and Bear River according to United States law and Territorial statutes of Utah and Idaho. However that may be, both bench and bar of this Territory, sustaining a long established custom, have long construed the law as recognizing rights to water for irrigation as acquired by appropriation and actual use only. There would seem to be a difference between appropriating and using water for years, making canals and ditches of an expensive nature to use more when Providence favors with an additional supply, and filing an intention or notice of such, of storing, taking out and selling water at some future time. Messrs. Bothwell & Co.'s recorded filing may hold good as against any other party or parties trying to do the same thing they contemplate doing, but they can hardly be expected to be allowed to strip the springs and streams of this region to take, as it were, the life blood out of our soil to enrich themselves. Possibly they contemplate nothing of the kind, but if not, they would perhaps do well to instruct their engineers to be a little more cautious about making injudicious remarks while measuring streams long appropriated and used. As before indicated, let them utilize all the surplus water they can without injury to any one, but no Shylock stripping of streams, nor spoiling of Bear Lake, nor arbitrary putting *settlers to the trouble* and expense of contending against their boasted millions of *money.*

In conclusion I would say that if the Government were to expend a small portion of the surplus in the overflowing national Treasury towards sinking experimental artesian wells and building reservoirs in the arid region for the encouragement of the struggling settlers, and assist in every legitimate way said settlers towards constructing reservoirs, the interests of the Government and the welfare of its citizens would be advanced thereby.

W. P. NEBEKER,
Special Irrigation Commissioner.

IRRIGATION NOTES.

The special commissioner for Rich County makes the following among other notes: In designating the quantity of water furnished or used, an irrigation stream has been taken as a unit or base of calculation. Such a stream is generally known in Rich County as the quantity of water one man can use in watering grain and vegetable crops, without waste of water or danger of injury to land by washing gullies, etc. The Swan Creek Irrigation Company designates such a stream as 20 inches wide, 2½ inches deep, under a pressure of 12 inches. By measurement I have ascertained that an irrigation stream, as issued to land holders in Laketown precinct, is (after bringing the water to a standstill against a dam) a sheet of water 30 inches wide and 3 inches deep, falling over a board one-half an inch thick. In this method of measurement the water falls from the surface; therefore there need be no doubt about the pressure or any complex contrivance to obtain it.

I have not attempted any miner's inch, cubic foot, or gallon measurements, for lack of time and necessary conveniences to obtain them. Few men, civil engineers, perhaps, not excepted, unless they are irrigators, know how many miner's inches, cubic feet, or gallons an irrigation stream would represent in any given time. All the granger cares to know is that when his turn comes to use the water he gets all he can well manage without waste or damage to his crops or land.

Mr. Nebeker also suggests, under the name of "Levee," what is believed to be a new system of irrigation in Utah. It consists in dividing up the land into plats by means of embankments of earth thrown up somewhat higher than the most elevated piece of land in the plat to be irrigated. The water is turned into the plat highest up on the canal or ditch, and is allowed to form a pond or lake, covering the plat. After remaining there as long as desired, a gate is opened and the water turned into the next plat, and so on till all the plats are irrigated.

The size of the plats are to be arranged somewhat according to the fall or slope of the land and the quantity of water available for use, as from twelve to twenty-four hours should be sufficient to fill and irrigate each plat. Said embankments can be made with plow and scraper, the same as a railroad grade. But where the land is free of rock what is called a ditcher is more profitable to use. It is a machine on four wheels and somewhat resembles a separator to a thrasher. It has a plow on one side and a carrier to take the earth to the other side of the machine.

In making a ditch, the dirt is thrown each side of the piece plowed, but with an embankment, the ditcher runs each side of where the embankment is to stand, throwing the earth together, much as back furrowing with a plow.

This system of irrigation is especially adapted to meadows on wide creek or river bottoms, having a fall of from 1 foot to 3 feet or a trifle more to the mile and plenty of water; changing the water from one plat to the other when necessary being about all the labor required in irrigation.

Streams and water they furnish in Bear River Valley, Rich County.

No. I.

Name.	Capacity in irrigation streams.		Shrinkage, 1889.	Remarks.
	April 1, ordinary seasons.	July 1, 1889.		
			Per cent.	
Saleratus Creek	10	Failed entirely	100	Inclined to run down early.
Woodruff Creek	20	4 streams	75	Depends mostly on the winter's snow.
Bear River	500	Failed entirely at Narrows.	100	Bed dry at Narrows.
Randolph Big Creek	17	4 streams	76	Not inclined to hold out well.
Randolph Little Creek	3	2 streams	33⅓	Continues good throughout the season.
Otter Creek	15	10 streams	33⅓	Do.
Wells or Sage Creek	1½	Failed entirely	100	Not inclined to hold out well.
Six Mile Creek	2	....do	100	Do.

Streams and water they furnish in Bear Lake Valley, Rich County.

No. II.

Name.	Capacity in irrigation streams.		Shrinkage, 1889.	Remarks.
	April 1, ordinary seasons.	July 1, 1889.		
			Per cent.	
Laketown Creek	4	3 streams	25	Generally keeps up well.
Braffit's Spring	2	1 stream	50	Usually holds out well.
Cottonwood Creek	2	do	100	Failed entirely.
Pine Kanyon Creek	½	do	100	Do.
Birch Hollow Creek	½	do	100	Do.
Edgar Valley	2	do	100	Do.
Meadowville Creek	2	½ stream	93¾	Inclined to fail early.
Bisbing Creek	¾	do	100	Failed entirely.
Swan Creek	30	15 streams	50	Generally a permanent stream.
Falula Spring Creek	1½	¾ stream	50	Do.
South Eden Creek	2	do	100	Failed entirely.
North Eden Creek	3	1 stream	33⅓	Does not generally hold out late.
Big Spring Creek	14	9 streams	35⅞	Generally a permanent stream.

An irrigation stream is all the water one man can use in irrigating grain and vegetable crops without waste of water or damage to land by way of washing gullies, etc. In Laketown precinct it has been ascertained by measurement to be a sheet of water 30 inches wide, 3 inches deep, falling over a board one-half an inch thick. In Garden City precinct it is designated as 20 inches wide, 2½ inches deep, under a 12-inch pressure.

Canal or ditch statistics of Bear River Valley, Rich County.

No. III.

Name of canal or ditch.	When built or first used.	Streams from which water is diverted.	No. of irrigation streams furnished by each.	Irrigated.	Irrigable.*
				Acres.	*Acres.*
Randolph Irrigation Co., Upper Big Ditch.	Apr., 1872	Randolph Big and Little Creek.	20	705	795
Randolph Irrigation Co., Lower Big Ditch.	May, 1881	Randolph Big Creek	17	550	585
Randolph and Woodruff Canal.	1886	Bear River	500	2,000	4,000
Bear River Irrigation Co	1883	do	500	1,500	500
Crawford and Dykins Ditch	1887	do	500	1,000	1,000
Beckwith Ditch	1887	do	500	8,120	
Otter Creek Canal Co	1889	Bear River†	500		‡10,000
North Otter Creek Ditch	1887	Otter Creek	15	300	300
South Otter Creek Ditch	1887	do	15	380	340
Booth, Crocker, and Crawford Canal.	1873	Bear River	500	8,000	2,000
Chapman and Strong Canal	1887	do	500	10,000	18,000
Woodruff South Ditch	1879	Woodruff Creek	20	400	5,000
W. K. Walton Ditch	1874	do	20	350	400
W. H. Lee's Ditch	1879	Bear River	500	400	200
Bear River Land and Stock Co.	1874	do		700	100
Laketown and Round Valley Canal Co.	May, 1888	Big Spring Creek	14	1,016	984
Meadowville Canal	July, 1872	do	14	402	50
Meadowville Lower Canal	July, 1889	do	14	1,250	
Cottonwood Ditch	1868	Cottonwood Creek	2	§252	
Braffit's Spring South Ditch	1868	Braffit's Spring Creek	2	§251	
Braffit's Spring North Ditch	1868	do	2	§95½	
Laketown No. 1, or North Ditch	1869	Laketown Creek	4	§650	
Laketown No. 2, or South Ditch	1872	do	4	§165	
Swan Creek Irrigation Co. Canal.	Jan., 1877	Swan Creek	30	‖1,505	495
Falula Spring North Ditch	May, 1882	Falula Spring Creek	1½	70	
Falula Spring South Ditch	Nov., 1883	do	1½	150	
Meadowville West Ditch	1874	Meadowville Creek	2	¶200	
Ira Nebeker Ditch	Apr., 1889	Big Spring Creek	14	400	

* Good land that could be irrigated by increased water supply in ditches now constructed.
† Is to come from it.
‡ *In process of* construction; 7 miles done, 23 miles undone.
§ *Only about half* enough water for the land irrigated.
‖ *Plenty of water* for all the land this ditch covers.
¶ *Hardly half* enough water for the land this ditch covers.

Reservoir sites for Bear River Valley, Rich County.

No. IV.

No.	Where situated.	Section.	Township.	Range.	Meridian.	Size.		Acres that could be irrigated by reservoirs.
						Area.	Depth.	
			North.	*East.*		*Acres.*	*Feet.*	
1	Head of Murphy Hollow	23	7	7	Salt Lake	100	15	1,000
2	Head of Saleratus Creek	7	7	7	....do	50	10	2,000
3	Dry Creek	7	8	7	....do	75	8	1,000
4	Dry Lake	18	8	8	....do	300	20	5,000
5	Meecham Cañon	19	8	8	....do	100	10	1,000
6	Narrows Bear River	14	18	*120	Sixth principal.	1,000	25	50,000
7	Narrows Bear River	10	18	*120	....do	†4,000	50	67,000
8	Cut-off Woodruff Creek	16	9	6	Salt Lake	500	10	5,000
9	Head of Woodruff Creek	9	9	6	....do	100	8	4,000
10	Middle Fork Woodruff Creek	19	9	6	....do	500	10	3,000
11	Left Fork Woodruff Creek	32	9	6	....do	75	8	4,000
12	Head of Cottonwood	30	12	5	....do	15	6½	200
13	Head of Birch Hollow	8	12	5	....do	10	9	100
14	Hollow north of Cottonwood Creek	10	12	5	....do	5	9	200
15	Edgar Valley	4	12	5	....do	40	12	200
16	Laketown Cañon	6, 7	12	6	....do	‡3	15	600
17	Tufts, Gebo, and Cheeny Cañons	17, 20	13	5	....do	†10	10	150
18	Head of South Eden Cañon	36	14	6	....do	10	9	200
19	North Eden Cañon	3	14	6	....do	20	13	} 350
20	North Eden Cañon	1, 2	14	6	....do	80	18	}

NOTE.—The acres above are not to be added, as the area that water could be brought upon is often covered partly or altogether by one or more other reservoirs, and the 67,000 acres includes what is covered by all the sites.

* West. † Dam 30 rods long, 60 feet high. ‡ Each.

REPORT OF COUNTY RECORDER.

DEAR SIR: Water rights for irrigation are recorded in this office as follows, to wit:

Saleratus Creek.—Fifteen claimants. Nature of right, first appropriation. Range in acres, from 80 to 720. Total, 3,440. Date, eleven in 1880, two in 1886, and one each in 1887 and 1889.

Woodruff Main Creek.—Has twenty-seven claimants. Nature of right, first appropriation. Range in acres, from 80 to 320. Total, 3,372. Date, nineteen in 1884, one in 1880, four in 1886, and one in 1887.

Otter Creek.—Has twenty-four claimants. Nature of right, first appropriation. Range in acres, from 40 to 3,940. Total, 6,945 acres. Date, twenty-one in 1880, one in 1881, and one in 1888.

Big Spring and Lake Town Streams.—Has seventeen claimants. Nature of right, first appropriation. Range in acres, from 21¼ to 360. Total, 1,414¼ acres. Date, ten in 1881, one in 1883, one in 1888, and one in 1889.

Big Spring Creek.—Has twenty-seven claimants. Nature of right, first appropriation. Range in acres, from 20 to 154. Total, 1,293¼ acres. Date, twenty-five in 1881, and one in 1888.

Gebo and North Creeks.—Has twenty-three claimants. Nature of right, first appropriation. Range in acres, from 10 to 500. Total, 1,820. Date, seventeen in 1881, one in 1882, one in 1887, and two in 1889.

Bear River.—Has fourteen claimants. Nature of right, first appropriation. Range in acres, from 80 to 6,000. Total, 20,720. Date, one in 1883, three, in 1885, four in 1886, two in 1887, and four in 1888.

NOTE.—Several claimants have no date at all.

The above does not, however, give the total of the lands in this county having vested or accrued rights to water for irrigation, as some land in some cases have recorded rights on more than one stream or source of water supply. Again, many rights for which water commissioner's certificates are held have not been recorded, but some of said certificates are so worded as to show the total number of acres hav-

ing rights on certain streams, and from the information thus obtained it seems that the following number of acres are entitled to water for irrigation and mill, in the respective precincts of this county, to wit:

Recorded to Woodruff precinct 6,812, shows 7,538.
Recorded to Randolph precinct 6,495, shows 7,000.
Recorded to Laketown precinct 1,414, shows 2,760.
Recorded to Meadowville precinct 1,691, shows 3,574.
Recorded to Garden City precinct 1,820, shows 2,500.
Recorded to Bear River stream precinct 20,720, shows, 30,000.

There is also recorded in his office a notice of intention to make a reservoir of Bear Lake, and a notice of intention to appropriate the surplus waters flowing into said lake and river.

Yours, very respectfully,

JOHN SNOWFALL,
Recorder Rich County.

W. P. NEBEKER, esq.,
Special Irrigation Commissioner.

REPORT ON SALT LAKE COUNTY.

By courtesy of J. Towsen Smith, civil engineer, water commissioner for Salt Lake City, the following data, respecting each stream flowing into Salt Lake County at the dates given, is presented:

City Creek.—April 23, 1889, 5,630,288 gallons per twenty-four hours at upper waterworks.

Red Butte.—April 26, 1889, 1,094,669 gallons per twenty-four hours.

Emigration Cañon Creek.—April 26, 1889, 1,013,444 gallons per twenty-four hours.

Parley's Cañon Creek.—April 27, 1889, 3,597,236 gallons per twenty-four hours.

Mill Creek.—May 4, 1889, 7,171,170 gallons per twenty-four hours.

Jordan River.—May 21, 1889, 141,161,315 gallons per twenty-four hours.

Big Cottonwood Creek.—May 23, 1889, 89,670,240 gallons per twenty-four hours; immediately following a heavy fall of rain would probably discharge from 9,000,000 to 10,000,000 gallons per twenty-four hours.

City Creek, at the head of Pleasant Valley.—April 25, 1889, 5,696,110 gallons per twenty-four hours. June 5, 1889, 9,879,340 gallons per twenty-four hours.

Parley's Creek.—May 27, 1889, 8,957,140 gallons per twenty-four hours. June 3, 1889, 4,725,735 gallons used on farms in Mountain Dell.

Little Cottonwood.—Not measured; would compare with Big Cottonwood this season.

Total number of gallons available for irrigation in the principal streams, 188,277,078.

RESERVOIR SITES.

Messrs. Jensen, of Mill Creek; C. A. Casto, of Brinton, and Joseph Scott, of Mill Creek, report the following respecting reservoirs:

Three lakes in Big Cottonwood, South Fork. Nos. 1 and 2 could be made to store 9,576,000 gallons by constructing dams 12 feet high and 150 feet long. Said dams could be raised 30 feet, thereby storing a much larger quantity.

No. 3 has a storage capacity of 21,142,800 by making dam 12 feet high and 150 feet long.

Silver Lake has a storage capacity of 27,183,600 gallons by raising dam 5 feet high and 600 feet long.

Twin Lakes have a capacity of 16,108,800 gallons each by the construction of dam 16 feet high and 200 feet long.

Dog Lake, a small pond, can be made to cover 10 acres with dam 16 feet high and 200 feet long, 40,272,000 gallons.

Lake Pheobe covers 2½ acres of ground.

Lake Mary covers 5 acres of ground; can be raised 16 feet with dam 50 feet long and store 20,136,000 gallons.

Lake Martha covers 4 acres; can be raised 12 feet with dam 200 feet long and store 12,081,600 gallons.

Lake Catherine can be made to cover 6 acres with dam 12 feet high and 150 long, and store 18,122,400 gallons.

Total capacity, 174,199,200 gallons.

In addition to the above there are two fine sites for reservoirs in Dry Creek Cañon, south of Little Cottonwood Cañon, with a storage capacity of over 150,000,000 gallons *each.*

LAND AND CANAL STATISTICS, SALT LAKE COUNTY.

The South Jordan Canal, taking water from the Jordan River (creek or spring), in the county of Salt Lake, shows: Length of the canal to be 19¼ miles. The upper end or first section is 3 miles long, 12 feet wide at bottom, and falls 3 feet to mile; the canal then narrows and the next section is 11½ miles long, 15 feet wide at bottom, and falls 19 inches per mile; the next section is 2½ miles long, 10 feet wide at bottom and falls 32 inches per mile, the next section is 2½ miles long, 8 feet wide at bottom and falls 5 feet per mile.

Total cost of canal was $87,000. Of this cost about $45,000 was in cash, and the balance in labor at $1.75 per day of ten hours, and $3.50 per day for man and team. The whole canal could probably be built now at a contract price of $75,000.

The canal was begun in 1869; finished 1878; first water used from it 1875.

This canal claims a first right to one-sixth of the water from Jordan River. This right is recorded in records of Salt Lake County.

This canal is owned by a corporation of which the legal name or title is South Jordan Canal Company, and the control is by directors.

The ownership is divided into 6,000 shares, of which 5,000 shares are now issued and in use; the balance of the shares are in treasurer's hands.

The par value of each share is $25; actual selling value per share is about $17.25. Each share was intended to furnish water to 1 acre. The present year, owing to scarcity of water, one share will give water for only two-fifths of an acre. The annual tax or assessment per share averages about 50 cents, which can be worked out at $1.75 per day of ten hours.

There are, in all, about 10,000 acres of arable land under this canal, but only 4,510 acres are now actually watered. Of this amount now irrigated there are in lucern or alfalfa, 1,800 acres; in other hay-making grasses, etc., 70; in small grains (wheat, oats, etc.), 2,400; in vegetables, corn, gardens, etc., 160, and orchards, 80.

Irrigation begins each year about April 15th and ends about October.

The Utah and Salt Lake Canal, taking water from the Jordan River, is 30 miles in length, and is divided into seven sections, respectively in length 9, 6½, 3, 2, 2, 4, 3¾ miles each. The width at the bottom of each section is 20, 16, 14, 12, 10, 8, 4 feet each. The fall of first six is uniform at 19 feet per mile; the last one has a fall of 2½ feet per mile.

Canal construction began in 1862; finished in 1888; was first used in 1882. It claims first right to one-sixth water in river. Recorded in county clerk's office, Salt Lake County. Incorporated with 10,000 shares at par value of $25 each; sells at $12.

Each share represents water for 1 acre. This year it gives water for only one-fifth of an acre.

Annual assessment, $1.50; payable in labor at $2 per day of 10 hours.

Under canal, 15,300 acres; actually irrigated, 6,325 acres. In alfalfa, 2,375 acres; n small grains, 3,200; in vegetables, corn, etc., 350, and in orchards, 200.

The Jordan and Salt Lake City Canal, taking water from the Jordan River, in Salt Lake County, is 39 miles in length and divided into three sections, respectively in length, 7, 15, 8 miles each. The width at the bottom is respectively 20, 20, and 10 feet each. The fall of each section is respectively 2½ feet, 19 inches, and 4 feet each per mile. Cost of canal was $235,853.84, all cash. Could probably be built now for same amount at contract price. Canal construction began in 1879; finished in 1882; was first used in 1882. It claims first right to one-third of the water in river. Recorded in records of Salt Lake County. Is incorporated.

The East Jordan Canal, taking water from Jordan River, is 19¼ miles in length and divided into one section. It is 15 feet wide at the bottom, and falls 19 inches per mile.

This canal claims first right to one-sixth of the water in river. Recorded in records of Salt Lake County. The par value of each share is $25; actual selling value per share is about $15. Each share was intended to furnish water to 1 acre.

There are in all about 10,500 acres of arable land under this canal; of this amount about 4,100 acres are now actually watered.

The North Jordan canal, taking water from the Jordan River, Salt Lake County, is divided into three sections, respectively in length $2\frac{3}{10}$, $2\frac{5}{10}$, and $2\frac{8}{10}$ miles each; in all $6\frac{6}{10}$ miles in length. The width at the bottom of each section is respectively 20 feet, 12 feet, and 4 feet each. The fall is, respectively, 8¼ inches per mile, 2½ feet, and 3 feet each per mile.

Canal construction was begun in 1850, and finished 1878; was first used in 1879.

Canal claims a first right to one-sixth of the water from Jordan River.

Recorded in records Salt Lake County.

It has four shares at par value of $25. Actual selling value, $12.50.

Under canal, 7,400 acres; actually irrigated, about 4,000 acres.

The Beckstead ditch canal, taking water from Jordan River, Salt Lake County, is 4½ miles in length.

Canal construction began in 1859; was finished in 1859; was first used in 1859.
It claims a first right to one-sixth water from the river. It is incorporated.
Under canal, 700 acres; actually irrigated, 700 acres.

The Parker ditch, taking water from Jordan River, Salt Lake County, is 3¼ miles in length.

Canal construction began in 1853; finished in 1865 or 1866; was first used in 1853.
This canal claims a first right to one-sixth water from river. Is owned by private owners. Under ditch, 300 acres; actually irrigated, 150. Of this amount, in small grains, etc., 125 acres; in vegetables, corn, etc., 25 acres.

The Butterfield ditch, taking water from Jordan River, Salt Lake County, is 10 miles in length, and is divided into two sections, respectively in length 7 and 3 miles each. The width at the bottom of each section is 2 feet and 1 foot each. Its fall is respectively 100 and 75 feet each per mile.

Cost of canal was $1,000, payable $100 cash and balance in labor at $2 per day of ten hours, and $3.50 per day for man and team.

Canal construction began in April, 1850; finished May 1, 1850; was first used 1850.
Recorded in county clerk's office July 13, 1880.
Is owned by private parties and is divided into twenty-three shares, at par value of $300 each; selling value at about $300. Each share represents water for 5 acres. This year it gives water for only 2 acres. Annual assessment, $5, payable in labor at $2 per day of ten hours.
Under ditch, 2,000 acres; actually irrigated, 300 acres. In alfalfa, 200 acres; in other hay-making grasses, etc., 12 acres; in small grains, 80 acres; vegetables, corn, etc., 80 acres; orchards, 25 acres. Irrigation from April 1 to October 1, each year.

The South Willow Creek canal, taking water from the South Willow River, Salt Lake County, is 2 miles in length and divided into one section. The width at bottom is 2 feet.

This canal is owned by private parties, and is divided into three shares. Each share was intended to furnish water to 10 acres.
There are in all about 700 acres of arable land under this canal; but only 30 acres are now actually watered. Of this amount there are in lucern or alfalfa, 30 acres; in small grains (wheat, oats, etc.), 8 acres, and in orchards, 4 acres.
Irrigation begins each year about April 15 and ends about October.
Suitable place for reservoir; could store a great quantity.

The Draper irrigating canal, taking water from Jordan River, Salt Lake County, is 8 miles in length, and is divided into three sections respectively in length 3, 3, and 2 miles each. The width at the bottom of each section is 4, 6, and 3 feet each. The fall is respectively 150, 50, and 25 feet each per mile. The last section is composed of three divisions.

Cost of canal was $15,000. Of this $1,000 was cash, and balance in labor at $2 per day of eight hours, and $4 for man and team. It could probably be built now at contract price of $5,000.

Canal construction began in spring of 1850; finished spring of 1889; was first used in 1850.
Recorded in records of the county court. Incorporated, with 1,010 shares, at par value of $30; sells at about $25. Each share represents water for 1 acre. This year it gives water for only one-tenth of an acre. Annual assessment 50 cents, payable in labor at $1.50 per day of eight hours.
Under canal, 10,000 acres; actually irrigated, 2,000 acres. In alfalfa, 300 acres; in hay-making plants, etc., 100 acres; in small grains (wheat, oats, etc.), 1,000 acres; in vegetables, corn, etc., 500 acres, and in orchards, 100 acres.
Irrigation begins each year April 15, and ends about October.
This canal claims a right in Big and Little Willow Creeks, South Dry Creek, Rocky Mouth, and springs, Bear Canyon, and one-half of the North Dry Creek to July 20, and two-thirds thereafter.
In the early settlement of the country the settlers took advantage of all the natural channels of the streams enumerated in the report, which accounts for the great change in the fall per mile. It will be understood that in assessment there is no cash debt incurred, outside of which labor does the repairing.

The Dry Creek ditch, taking water from Dry Creek River, Salt Lake County, is 5 miles in length and is divided into two sections, respectively in length 2 and 3 miles each. The width, at bottom, of each section is respectively 5 and 4 feet each, and the fall is 20 and 25 feet each per mile.

Cost was $5,000. Of this, $200 was cash and balance in labor at $2 per day of eight hours and $3.50 for man and team. It could probably be built now at contract price of $3,500.

Canal construction began in spring of 1869; finished, 1874; was first used in spring of 1870.

It claims a first right to one-half of the water in Dry Creek and first surplus. It is owned by an association and is divided into 3,200 shares, at par value of $5; selling value about $1.75. Each share represents water for 1 acre. This year it gives water for only one-fourth of an acre. Annual assessment, 25 cents, payable in labor at $1.50 per day of eight hours.

Under ditch, 6,000 acres; actually irrigated, 2,000 acres. Of this amount now irrigated there are in lucern or alfalfa 1,000 acres; in small grains (wheat, oats, etc.), 1,000. Irrigation begins each year about May 1 and ends about October.

The East Jordan irrigation canal, taking water from Little Cottonwood Creek, Salt Lake County, is 5¼ miles in length, and is divided into three sections, respectively in length 2, 1½, and 2 miles each. The width at the bottom of each section is respectively 6, 6, and 5 feet each. The fall of each section is respectively 20, 20, and 15 feet each per mile.

Cost of canal was $1,550 cash, and balance in labor at $2 per day of ten hours, and $4 for man and team. It could probably be built now at contract price of $10,000 in consequence of enlargement.

Canal construction began in 1866; finished, 1867; was first used in 1866.

It claims a surplus right to water from Little Cottonwood Creek and River. Recorded in county clerk's office of Salt Lake County, May 15, 1886.

It is owned by private parties, and is divided into 766¼ shares, all of which are issued and in use. Par value per share is $20. Each share represents water for 2 acres. This year it gives water for only ¼ of an acre. Annual assessment, 20 cents, payable in labor, at $2 per day of ten hours.

Under canal, 1,650 acres; actually irrigated, 1,200 acres. In alfalfa, 600 acres; in small grains, etc., 600 acres.

Irrigation begins each year about April 15, and ends about August 20.

The Cahoon and Maxfield canal, taking water from Little Cottonwood River, Salt Lake County, is 5 miles in length and is one section; being 2 miles long, 8 feet wide at bottom, and falls 10 feet per mile.

The construction of the ditch was begun in 1849; finished in 1850; and was first used in 1850.

It claims a prior right to five-eighteenths of the water in Little Cottonwood Creek. Recorded in the county clerk's office December 5, 1856.

It is owned by an association and is divided into 3,000 acres. The annual assessment per acre averages about $1.50 payable in labor at $1.50 per day of eight hours. There are in all about 3,000 acres under ditch; actually irrigated, 2,626 acres. Of this amount now irrigated there are in lucern or alfalfa, 900 acres. In other hay-making plants or grasses, 450. In small grains (wheat, oats, etc.), 800. In vegetables, corn, gardens, etc., 326, and in orchards, 150 acres.

Irrigation begins each year about April 5 and ends about October 30.

The Tanner ditch, taking water from Little Cottonwood, Salt Lake County, is 4¼ miles in length, and is divided into three sections, respectively in length one-fourth, one-half, and 3 miles each. The width of bottom of each section is respectively 8 feet.

Canal construction was begun in the fall of 1848; finished spring, 1849; was used first in 1849.

It claims a right to two-ninths of the water from Little Cottonwood River and Creek. Recorded in the minutes of the county court of 1856.

The ownership is divided into 1,288 acres. Each share was intended to furnish water to 1 acre. This year it gives water for only one-half an acre.

The annual assessment per acre averages about 20 cents, payable in labor at $2 per day of ten hours.

There are in all about 1,288 acres under canal but only one-twentieth is actually irrigated.

Of this amount now irrigated there are in lucern or alfalfa, 444 acres; in other hay-making plants, grasses, etc., 200; in small grains (wheat, oats, etc.), 300; in vegetables, corn, gardens, etc., 244, and in orchards, 100 acres.

Union and Jordan irrigating ditch, taking water from Little Cottonwood River, Salt Lake County, is 5 miles in length, and is divided into three sections, two respectively of three-quarters of a mile and one of 3¼ miles. The width at bottom of each section is respectively 10, 8, and 6 feet each.

Construction of ditch began in 1850; finished 1850; was first used 1850.

This ditch claims a prior right to five-eighteenths of the water in Little Cottonwood River and Creek. Recorded in the records of the Salt Lake County court, December 5, 1856.

It is owned by association, and is divided into acre shares. The annual assessment per acre averages $15, payable in labor at $2 per day of eight hours.

There are, in all about 2,200 acres under ditch, but only about 1,800 acres actually watered. Of this amount now irrigated there are in lucern or alfalfa, 600 acres. In

other hay-making plants, etc., 200; in small grains (wheat, oats, etc.), 700; in vegetables, corn, gardens, etc., 200, and in orchards, 100 acres.

Irrigation begins each year about April 15 and ends about November 1.

The original name of Union and Jordan irrigating ditch was known in the county records as the Union ditch, to convey the waters to the Hammond survey.

The Walker ditch, taking water from the Little Cottonwood Creek, Salt Lake County, is 4 miles in length, is in one section, and is 3½ feet wide at bottom.

Construction of ditch was begun in 1849, and finished in 1850; was first used in 1849.

This canal claims a first right to one-ninth of the water in Little Cottonwood Creek.

The ownership is divided into 500 acres. The present year each share gives water enough for only one-thirtieth of an acre. The annual assessment per acre averages about 10 cents.

There are in all about 500 acres under the ditch, but only 20 acres actually irrigated. Of this amount now irrigated there are in lucern or alfalfa, 150 acres; in other hay-making plants, grasses, etc., 100; in small grains (wheat, oats, etc.), 200; in vegetables, corn, gardens, etc., 25; and in orchards, 25 acres.

Irrigation begins each year about April 1 and ends about October.

The Nichol ditch canal, taking water from Little Cottonwood, Salt Lake County, is 5 miles in length, and is divided into four sections, respectively in length 2, 1, and one-half miles each. The width at bottom of each section is respectively 6, 5, and 5 feet each. The fall is respectively 25, 10, and 30 feet per mile, and the next section 1½ miles to the terminus, 2 feet wide and 10-foot fall.

Cost of canal was $2,000; of this, $300 was cash, and the balance in labor at $3 per day of ten hours, and at $5 per day for man and team.

Canal construction began in April, 1877, and finished May, 1877; was first used in May, 1877. It claims a surplus right to water from Little Cottonwood Creek. Not recorded. It is owned by association, and is divided into 369 shares, at par value of $10; sells at $15. Each share was intended to furnish water to 1 acre. The annual assessment averages about 25 cents. There are in all 997 acres under the ditch. Actually irrigated, 368 acres. Of this amount now irrigated there are in lucern or alfalfa, 220 acres; in other hay-making plants or grasses, 5; in small grains (wheat, oats, etc.), 120; in vegetables, corn, gardens, etc., 17½, and in orchards, 5½ acres.

Irrigation begins each year about May.

Richards Ditch, taking water from Little Cottonwood Creek, Salt Lake County, is 2 miles in length, and is divided into two sections, respectively in length, 1¼ and three-quarter miles each. The width at bottom of each section is respectively 8 and 2 feet each.

Canal construction began in 1849; finished, 1849; was first used in 1849.

This canal claims a first right to one-ninth of the water in Little Cottonwood River. It is owned by private parties and is divided into 415 acres.

Under the ditch there are about 415 acres, but only 220 acres actually irrigated. Of this amount now irrigated there are in lucern or alfalfa, 45 acres; in other hay-making plants or grasses, 92 acres; in small grains (wheat, oats, etc.), 45 acres; in vegetables, corn, gardens, etc., 25 acres, and in orchards, 13 acres.

Irrigation begins each year about April 12 and ends about August 30.

The South Dry Creek Big Cottonwood Canal, taking water from the South Dry Creek River, Salt Lake County, is 1 mile in length, and is 1 mile long, 2 feet wide at bottom, and falls 1 foot.

Cost was $100 cash, and balance in labor at $1.50 per day of eight hours, and $3 for man and team.

Canal construction began in 1848, and finished 1848; was first used 1848. It claims a first right to all the water in South Spring River. Under the canal there are 100 acres; actually irrigated, 100 acres. Of this amount now irrigated there are in lucern or alfalfa, 40 acres. In small grains (wheat, oats, etc.), 49 acres. In vegetables, corn, gardens, etc., 5 acres, and in orchards, 6 acres.

Irrigation begins each year about May 1 and ends about September 15.

Brown and Sanford Ditch, taking water from Big Cottonwood Creek, is 3¼ miles in length and is divided into three sections, respectively in length, ¼, 1½, and 1½ miles each. The width at the bottom of each section is respectively 6, 5, and 3 feet each.

Canal construction was begun in 1872 and finished 1874; was first used 1873.

This canal claims a right to one-fifth of the water from Big Cottonwood Creek. Is recorded in the county recorder's office.

The ownership is divided into 195 shares, which are now issued and in use. Par value of each share is about $100. Selling values $100. Each share represents water *to 13⅓ acres.* This year it carries no water. Annual assessment, $2, payable in labor *at $1.50 per day of* ten hours.

Under the ditch there are 2,200 acres; actually irrigated, only 25 acres. Of this amount, there are lucern or alfalfa 800 acres; in other hay-making plants or grasses, 100 acres; in small grains (wheat, oats, etc.) 250 acres; in vegetables, corn, gardens, etc., 40 acres; and in orchards, 40 acres.

Irrigation begins each year about May 1 and ends about October.

The Big Creek has three forks or branches. The first branches off about half a mile from the head and is known as the Miller Fork; it waters about 385 acres. About 2½ miles farther down it forks again, and they are known as the North and South Forks. Between the Miller Fork and the other forks, 425 acres are watered. The South Fork waters about 1,110 acres. The North about 555 acres.

Upper canal, taking water from Big Cottonwood Creek, is six miles in length, and is divided into two sections, respectively in length, 4 and 2 miles each. The width at bottom of each section is respectively 10 and 8 feet each. The fall of each section is respectively 20 and 10 feet each per mile.

Canal construction began in 1850 and finished in 1852; was first used in the spring of 1850.

The ownership is divided into 10½ shares, which are now issued and in use. Each share was intended to furnish water to 130 acres. The present year, it gives water for only 43½ acres. Annual assessment $39, payable in labor at $1.25 per day of eight hours.

Under the canal, 1,630 acres; actually irrigated, 1,556 acres. Of this amount, alfalfa or lucern, 778 acres; in small grains (wheat oats, etc.), 518 acres; in vegetables, corn, gardens, etc., 200 acres, and in orchards, 60 acres.

Irrigation begins each year about May 1 and ends about September.

Big Cottonwood Creek was arbitrated and divided into six shares. There was no record made of the creek that we know of until 1879, when most of the people agreed to arbitrate. The shares were divided according to the acreage.

Big Cottonwood Tanner Canal, taking water from Big Cottonwood Creek, is 4½ miles in length, and is divided into three sections, respectively, in length one-quarter, one-half and 3¾ miles each. The width at bottom of each section is respectively 8, 8, and 6 feet each.

Canal construction began in fall of 1848, and finished spring, 1849; was first used in spring, 1849. It claims a first right to one and one-quarter of the water from Big Cottonwood Creek in low stage of water.

It is owned by private parties and is divided into 1,605 shares, now issued and in use, at par value of $100. Each share represents water for 1 acre. The present year it gives water for only one-twentieth of an acre. Annual assessment, 20 cents, payable in labor at $2 per day of ten hours.

Under canal, 1,605 acres, but only one-twentieth now actually irrigated. Of this amount, alfalfa or lucern, 605 acres. In other hay-making grasses, 200 acres. In small grains (wheat, oats, etc.), 500 acres. In vegetables, corn, gardens, etc., 200 acres, and in orchards, 100 acres.

Irrigation begins each year about April 15 and ends about October 1.

Green Ditch, taking water from Big Cottonwood Creek, is 2½ miles in length, and is divided into two sections, respectively in length 1 and 1½ miles each. The width at bottom of each section is, respectively, 8 and 6 feet each. The fall of each section is, respectively, 10 and 6 feet each per mile.

Cost was $200 cash, and balance in labor at $1.50 per day of ten hours, and $3 for man and team.

Canal construction began in 1848, finished in 1849, and was first used in 1848.

It claims a first right to one-sixth of the water from Big Cottonwood River. The ownership is divided into 625 shares.

Under ditch, 625 acres. Actually irrigated, 625 acres. Of this amount, alfalfa or lucern, 62 acres; in other hay-making grasses, etc., 126 acres; in small grains, etc., 109 acres; in vegetables, corn, etc., 76 acres, and in orchards, 12 acres.

Irrigation begins about May 1 and ends about September 1.

There are 240 acres of pasture and timber which need irrigation.

A. H. Neff Ditch, taking water from Mill Creek, is one-half a mile in length and is one section, being 2 feet wide at bottom, and falls 2 feet per mile.

Canal construction was begun in 1855 and finished in 1855; was first used in 1855.

The ownership is divided into 4 shares, at par value of $1,700, sells at $1,700. Each share represents water for 34 acres.

The present year it gives water for only 6½ acres. Annual assessment $2, payable in labor at $1.50 per day.

Under ditch there are 225 acres and only 25 acres are actually irrigated. In vegetables, corn, gardens, etc., 10 acres; orchards, 15 acres.

Irrigation begins each year about March 1 and ends about November.

At present there is about 24 inches of water in the ditch. This, when carried one-half mile will lose in seepage *and evaporation* nearly one-half, so that it is impossible

to irrigate any lucern from this small stream. Can be used only on orchards and gardens.

Alva Keller Ditch, taking water from Mill Creek, is 1¼ miles in length and 3 feet wide at bottom.

Cost was $600, payable in labor. Could probably be built at contract price of $400.

Canal construction began in 1848 or 1849, and water was first used from it in 1848 or 1849.

Each share represents water for 40 acres. This year it gives water for only 8 acres.

Under ditch there are 200 acres; none actually irrigated.

Irrigation begins each year about April 1 and ends about October.

The Keller Ditch was dug in 1848 or 1849, and was enlarged in 1871, and at the arbitration was awarded 4.24 shares of the waters of Mill Creek.

Franklin and John Neff Canal, taking water from Mill Creek, is one-half mile in length, 2½ feet wide at bottom, and falls 40 inches to the mile

Cost of canal was $200. Of this amount $50 was cash. Could probably be built now at contract price of $150.

Canal construction was begun in 1875, and finished in 1875; was first used in 1875.

This canal claims a first right to two shares of surplus water from Mill Creek; is recorded in the decisions of the water commissioners of Salt Lake County. Each share represents water for 34 acres. This year it gives water for only 5 acres. Annual assessment averages about $5. Under ditch there are 200 acres, and 25 are actually irrigated. Of this amount, in lucern or alfalfa, 3 acres; in small grains (wheat, oats, etc.), 10 acres; in vegetables, corn, gardens, etc., 5 acres; and in orchards, 7 acres.

Irrigation begins each year about March 1 and ends about November 1.

There are no shares in the ditch, but each person owns according to the amount he cultivates. The three last summers the water has failed.

Brigham Young Ditch, taking water from the Mill Creek, is one and one-half miles in length. The first section is one and one-half miles in length, five feet wide at bottom, and falls twenty feet per mile. Could probably be built now at contract price of $1 per rod.

Canal construction began in 1852, finished in 1852.

This canal claims a first and second right to fourteen out of sixty shares water from Mill Creek; is recorded in decisions of the water commissioners of Salt Lake County. The ownership is divided into 432 shares. Actual selling value per share is about $75. Each share represents water for 1 acre. This year it gives water for only one-eighth of an acre. Annual assessment, 10 cents. Under ditch, 500 or 600 acres. Actually irrigated, only 432 acres. Of this, lucern or alfalfa 145 acres; in small grains (wheat, oats, etc.,) 50 acres; in vegetables, corn, gardens, etc., 20 acres, and in orchards 20 acres.

Irrigation begins each year about April and ends about October.

There has been no water for secondary claimants for two years.

The Chrisman, Bryon, Stillman, Skidmore, and Russell Canal, taking water from Mill Creek, is 5 miles in length.

It cost $1,500. Of this amount $250 was in cash and the balance in labor at $2 per day of ten hours, and $4 for man and team. Could probably be built now at contract price of $1,000.

Canal construction began in 1848 and finished in 1874; was first used in 1848.

It claims a first right to one-twentieth of the water in Mill Creek; is recorded in Salt Lake County.

It is owned by private parties, with six shares.

Each share was intended to furnish water to 34 acres. This year it gives water for only 5 acres. The annual assessment is 15 cents.

Under canal there are, in all, 1,500 acres; actually irrigated, only 225 acres. Of this amount, lucern or alfalfa, 145 acres; in small grains (wheat, oats, etc.), 40 acres; in vegetables, corn, gardens, etc., 15 acres, and in orchards 25 acres.

Hoagland Ditch, taking water from Mill Creek, is 3 miles in length, and is divided into two sections, respectively, in length, 1¼ miles each. The width at bottom of each section is, respectively, 4 and 2½ feet. The fall of each section is 15 and 20 feet per mile.

Cost, $500. Of this, $50 was in cash, and balance labor at $2 per day of ten hours, and $4 for man and team.

Canal construction began in 1849 and finished 1849; was first used 1849.

It claims a first and second right to twenty-three sixtieths of water in Mill Creek. Is recorded in records of water rights of Salt Lake County. It is owned by private parties, with 55 shares. Each share was intended to furnish water to 34 acres. This year it gives water for only 6 acres. The annual assessment is $6.50, payable in labor *at $1.50 per day of* eight hours and $3 per share in cash.

Under ditch there are, in all, about 1,000 acres. Actually irrigated, only 175 acres.

Of this, in lucern or alfalfa, in early season, 250 acres; in small grains (wheat, oats, etc.), 300 acres; in vegetables, corn, gardens, etc., 70 acres, and in orchards 60 acres.

Irrigation begins each year about April 1 and ends about October.

The Edward White ditch, taking water from Mill Creek, is 1¼ miles in length, 3 feet wide at bottom, and falls 5 feet per mile.

Cost $1,000. Of this $200 was in cash and the balance in labor at $2.50 per day of ten hours.

Canal construction began in spring of 1872 and finished 1872; was first used 1872.

This canal claims a first and second right and third right to water from Mill Creek; is partly recorded in records of Salt Lake County. It is owned by private parties.

Under ditch there are in all about 354 acres; actually irrigated, 234 acres; of this, in lucern or alfalfa, 126 acres; in small grains (wheat, oats, etc.), 113 acres; in vegetables, corn, gardens, etc., 10 acres, and in orchards, 11 acres.

Irrigation begins each year about April and ends about October.

Turnbow ditch, taking water from Parleys Creek, is 2 miles in length and 4 feet wide at bottom.

Canal construction was begun in 1849 and finished 1849; was first used 1849.

It claims a first right to water from Parleys Creek. It is owned by private parties. The annual assessment is about 20 cents, payable in labor at $1.50 per day of eight hours.

Under ditch there are in all about 500 acres; actually irrigated, 500 acres; of this, in lucern or alfalfa, 30 acres; in other hay-making plants or grasses, 50 acres; in small grains (wheat, oats, etc.), 210 acres; in vegetables, corn, gardens, etc., 200 acres, and in orchards, 10 acres.

Irrigation begins each year about May 1 and ends about October 1.

Sperry ditch, taking water from Parleys Creek, is 1½ miles long and 4 feet wide at bottom.

Cost of canal was $1,000 cash and balance in labor at $1.50 per day of eight hours. Could probably be built now at contract price for $600.

Canal construction was begun in 1849 and finished 1849; was first used 1849.

It claims a first right to one part of water below Kennedy ditch. It is owned by private parties, with 260 acre-shares, at par value of $10 each. Each share represents water for 1 acre. This year it gives water for only one-fifth of an acre.

The annual assessment is about 20 cents, payable in labor at $1.50 per day of eight hours.

Under ditch there are in all about 260 acres. Actually irrigated, 260 acres. Of this, in lucern or alfalfa, there are 25 acres; in other hay-making plants or grasses, 25 acres; in small grains (wheat, oats, etc.), 40 acres; in vegetables, corn, gardens, etc., 37 acres, and in orchards, 3 acres.

The Kennedy ditch, taking water from Parleys Cañon, is 4 miles in length. Is the same width and fall all along; 4 feet wide and 5-foot fall per mile.

Total cost, $8,294.40, payable in labor at $1.50 per day of ten hours, and $3.50 per day for man and team. It could be built now for same.

Canal construction began in 1849, and finished 1850; was first used 1849.

It claims a first right to two-fifths of the water from Parleys Cañon. Is recorded in Salt Lake County court records. It is owned by private parties, with 876 shares, all of which are now issued and in use. Each share represents water for 1 acre. This year it gives water for only one-tenth of an acre. The annual assessment is about 50 cents, payable in labor at $1.50 per day of ten hours.

Under ditch there are in all 876 acres. Actually irrigated only 876 acres. Of this, in lucern or alfalfa, there are 175 acres; in other hay-making plants or grasses, 60 acres; in small grains (wheat, oats, etc.), 350 acres; in vegetables, corn, gardens, etc., 175 acres, and in orchards, 116 acres.

Irrigation begins each year about May 1 and ends about September 15.

At the time this ditch was first used all of the water flowing from Parleys Cañon was used, and none passed the dam of this ditch. Hence we claim all the water in Parleys Cañon, when needed, to the exclusion of all other ditches or claims, by reason of this right. Was constructed with pick and shovel, and would have to be now. Most of the ditch is on a side hill; the fall being good, there is no seepage.

Saunders ditch, taking water from Parleys Creek, is 1¼ miles in length, 3 feet wide at bottom, and falls 50 feet per mile.

The ownership is divided into 270 shares, all of which are now issued and in use. Each share represents water for 1 acre. This year it gives water for only one-half an acre. The annual assessment, 10 cents, payable in labor at $2 per day of eight hours.

Under ditch there are in all about 270 acres. Actually irrigated, 135 acres. Of this, in lucern or alfalfa, there are 100 acres; in other hay-making plants or grasses, 25 acres; in small grains (wheat, oats, etc.), 75 acres; in vegetables, corn, gardens, etc., 30 acres; and in orchards, *40 acres.*

Irrigation *begins each year about* April and ends about November.

Parleys irrigating canal and ditch, taking water from Parleys Creek, is 3½ miles in length. First section is 3½ miles long, 3 feet wide at bottom, and falls 4 feet per mile. Total cost was $3,000. Of this $1,000 was in cash, and balance in labor at $2 per day of ten hours, and $4 per day for man and team. It could probably be built now at contract price of $3,000. Canal construction began in 1878, and finished in 1881; was first used in 1878. It claims a second right to water in Parleys Creek. Recorded in the records of county court. Is owned by private parties. One hundred and twenty shares are now issued and in use. Par value of each share is $30. Actual selling value, $75. Each share represents water for 5 acres. This year it gives water for only 1 acre. The annual assessment, $2; payable in labor at $2 per day of eight hours.

Under canal and ditch, 1,200 acres. Actually irrigated, 400 acres. Of this, in lucern or alfalfa, there are 300 acres. In small grains (wheat, oats, etc.), 50 acres. In vegetables (corn, gardens, etc.), 25 acres; and in orchards, 25 acres.

Irrigation begins each year about March 15, and ends about July.

The Huskinson ditch, taking water from Parleys Creek, is 1 mile long and 1½ feet wide at bottom.

It claims a primary right to water from Parleys Creek. It is recorded in the county clerk's office of Salt Lake County. It is owned by private parties, with 25 acres. The annual assessment per acre is $1.60, payable in labor at $2 per day of ten hours.

There are in all about 150 acres under ditch. Only 25 acres actually irrigated. Of this, lucern or alfalfa, 20 acres; in small grains (wheat, oats, etc.), 24 acres, and in orchards 1 acre.

REPORT ON SAN JUAN COUNTY.

In addition to information already given I would state that about 1,000 acres of the arable land in the county lies adjacent to, and could be irrigated at considerable expense by ditches from, the San Juan River.

The bulk of the remainder lies around the base of the Blue and Elk Mountains at an elevation of from 6,000 to 7,000 feet and on an elevated plateau known as the Cedar Ridge, lying southwest of the Elk Mountains, between the Colorado and the San Juan Rivers, the mean elevation of which is about 5,000 feet; the soil and climate of the great bulk of this land is well adapted for raising grain and all kinds of fruits and vegetables that are raised in a temperate climate. The mountains afford a good supply of timber and nothing is lacking to make this section a very desirable place to dwell in except water. This want could be supplied to a great extent by a proper system of water storage in the cañons and washes around the bases of the mountains.

There are not to exceed three quarter sections of land in the county on which patents have been issued. This land belongs to the Pittsburgh Cattle Company, and is situated near the south base of the La Salle Mountains. On account of the proposition to turn the county into an Indian reservation all lands in the county were withdrawn from the market on the 13th day of November, 1888, and still remain in that condition.

As the county is unsurveyed and very sparsely inhabited, I am not able to give all of the details asked for by the governor, but Hon. F. A. Hammond, who is one of the selectmen of the county, expects to meet the Senate committee in Salt Lake and can give them personally all of the information that they desire in regard to the climate, soil, topographical features, etc., of the different sections.

PETER ALLAN,
County Clerk.

REPORT FROM SCIPIO, MILLARD COUNTY.

George Munroe writes the governor that——

There is, about 8 miles south of Scipio, on the ridge, a natural lake which we use for storing our water in the winter to irrigate in the summer. The lake now is about 2 miles long and 1 mile wide; when we can get it full it affords sufficient water to mature our crops.

This lake could be made to hold ten times this amount. It is a natural basin for 4 or 5 miles above its present dimensions. It has been supposed that the Sevier River could be brought into this lake; if it can, water can be stored here to irrigate thousands of acres of land that is now a barren waste. In this valley the river runs to waste all winter. I think it is worth investigating; at least, if a survey was made to find if it was possible to get the river to come into this lake, it would furnish homes for a great many people. It would be impossible to find a more favorable spot for a reservoir.

REPORT ON KANE COUNTY.

Three-fourths of the surface of Kane County are mountains covered with timber. The other one-fourth is arid land, all of which would produce good crops by being *irrigated. The amount* now cultivated in comparison to what could be by an increase

of water is very small. I will give an account of each of the principal streams separately.

East Fork of the Rio Virgin.—On the headwaters of East Fork of this stream there are about 300 acres under cultivation, about one-fourth of which is irrigated by numerous small ditches.

Ten miles below, the cañon opens out into what is called Long Valley, with an average width of one-half mile and 7 miles in length. In this valley are situated the towns of Glendale, Orderville, and Mount Carmel, Glendale occupying the north, and Mount Carmel the south end of the valley, while Orderville is centrally located.

Between Orderville and Mount Carmel, in what is known as the cove, there are 50 acres of good land that could be cultivated by an extension of the Orderville ditch and an increase of water.

About 1 mile below Mount Carmel a stream called the Muddy comes in from the west, on which about 60 acres are now cultivated, and 200 more could be by an increase of water. From Mount Carmel the course of this branch of the Virgin for 7 miles is a succession of narrow and small coves, containing in the aggregate about 300 acres of good land. There is a small side cañon at nearly every cove that could be dammed up and filled from the main stream in the winter season with sufficient water to irrigate the cove. This is also the case with the Muddy branch. Many of these reservoirs will be made in time by private enterprise, but in the mountains at the head of this stream, some 10 miles above Glendale, are located several large sites which could be used to hold the water up in the spring. Being natural reservoirs, they are used now by parties who farm 15 or 20 acres near them.

One of these sites, owned by R. G. Jolley, could be made to cover 50 acres 6 feet deep at an expense of $500. Another owned by R. G. Jolley & Co., could be made to cover 100 acres 15 feet deep at an expense of $500. Another, owned by E. Potter & Co., could be made to cover 100 acres 8 feet deep at an expense of $500. And yet another, owned by Mr. Levanger, could be made to cover 40 acres 10 feet deep at an expense of $500.

These sites are all located in the mountains among pine timber and removed from all danger of floods, which might break or fill them with mud or débris. All the present owners ask is to be allowed to use the same amount of water from the reservoirs that they now use. There is always an abundance of snow-water to fill these reservoirs and plenty of use for the water in Long Valley.

Kanab Creek.—On the headwaters of Kanab Creek are some very fine farms, comprising about 300 acres of land under cultivation and twice that amount of pasture land under fence. There are 1,000 acres of good land that could be cultivated by an increase of water and one good reservoir site, on the property of Wooley and Seymiller, which could be made to cover 10 acres 10 feet deep at an expense of $1,000.

Immediately below these farms, at the lower end of the valley, the mountains come almost together, and by building a dam 20 rods long and 100 feet high a reservoir could be made that would cover one-half mile square at an average depth of 30 feet.

Eight miles below this point S. M. Anderson has a reservoir in successful operation. It is a little cove on one side of the narrow valley with an area of about 5 acres. He has constructed a ditch 5 miles long to fill it, which he did last spring in one week, to the depth of 8 feet. He is cultivating 15 acres this season, and will not use half the water. He intends to irrigate 50 acres from this reservoir next season.

Twenty-five miles down from the head of Kanab Creek is the town of Kanab, the county site of Kane County. There are no good reservoir sites in the cañon above it, but along the foot-hills on both sides are numerous good small sites which could be filled in the winter.

Johnson Run.—Along this stream for 20 miles the valley has an average width of one-half mile, all good land, and many side cañons that would make good reservoirs at a small expense. The only land cultivated on this stream is the Schutampah ranch and about 150 acres at the town of Johnson, 12 miles east of Kanab, and this is all watered from springs, the streams being dry during the summer season, except when it rains, when it is a rushing torrent, which is also the case in the spring for two or three months.

But the grandest reservoir site in the county is situated about 3 miles below the town of Johnson. Here is a long valley running east and west, and the Johnson Run crosses right through the center of it and breaks through the mountains on the south side. The gap where it breaks through is not more than one-quarter mile wide, and by building a dam across this gap 50 feet high the water would be backed along the valley for 5 miles in length and 1 mile in width. About 2 miles below this gap is situated about 1,600 acres of the best of land.

Kane County is situated over the southern rim of the Great Basin and falls rapidly towards the Colorado River. The average fall of snow in our mountains is not less than 15 feet. In the spring of the year and during summer rains the amount of water that runs into the Colorado River by hundred of streams that are dry at other times is something that can not be *estimated*. The major part of the water could be held

back by the construction of reservoirs. The amount of land, water, and reservoir sites is practically unlimited; all that is lacking is capital and labor to utilize them. We have a semi-tropical climate and one of the best and most extensive stock ranges in the Territory. But the country is sparsely settled and the people are poor and without the means to develop the great resources of the country.

If the Government would take hold of some of these large reservoirs, and thereby furnish employment to the people, they would then be able to construct many smaller ones by private enterprise, and so the money expended would be doubly used in the one direction.

H. E. BOWMAN,
County Surveyor.

RECAPITULATION OF KANE COUNTY.

Name of ditch and valley in which located.	Date when first built or in use.	Stream from which the water is diverted.	Number acres irrigated.	Good land that could be cultivated by an increase of water.	Good land that could be cultivated by new ditches and reservoirs.
Long Valley:				*Acres.*	*Acres.*
Glendale east ditch*	1871	East Fork of Rio Virgin	150	.....	.....
Glendale west ditch*	1871	....do	150	.....	.....
Orderville west ditch*	1871	....do	300	.....	50
Mount Carmel City ditch*	1871	....do	300	200	300
Mount Carmel east ditch*	1871	....do	75	.....	.....
Upper Kanab:					
Upper Kanab ditch†	1876	Kanab Creek	300	500	500
Sink Valley:					
Sink Valley ditch†	1876	Springs	50	500	.....
Kanab:					
Kanab City ditch*	1870	Kanab Creek	200	200	500
Kanab field ditch†	1870	....do	300	300	1,000

Name of ditch and valley in which located.	Average fall of snow in mountains.	Water per second flowing through her stream where ditch is taken out.	Nature of soil.	How often irrigated.	How long at a time.
Long Valley:	*Feet.*	*Cubic feet.*			*Hours.*
Glendale east ditch*	15	18	Clay	Every 15 days	5
Glendale west ditch*	15	14	....do	....do	5
Orderville west ditch*	15	10	....do	Every 27 days	12
Mount Carmel City ditch*	15	5	....do	Every 20 days	10
Mount Carmel east ditch*	15	1	....do	....do	10
Upper Kanab:					
Upper Kanab ditch†	15	7	....do	Every 18 days	8
Sink Valley:					
Sink Valley ditch†	15	1	....do	Once a year	10
Kanab:					
Kanab City ditch*	15	5	Sandy	Every 7 days	1
Kanab field ditch†	15	3	....do	Every 12 days	2

NOTE.—Irrigation season begins April 1 and ends October 1.
*Irrigates orchard, garden, and hay field crops.
†Irrigates hay and field crops.

There have been no crops lost for the want of water, but crops are materially damaged every year from this cause. Clay soil requires more water than sandy soil. There is no particular difference in the amount of water used for different kinds of crops while the crops are growing, but those crops which are longest growing have to be watered longer; hence require more water.

REPORT ON MOUNT PLEASANT PRECINCT, SAN PETE COUNTY.

The water supply is received from the East Mountains, lying about 4 miles east of this town, through five main channels, which are named as follows: (1) Cedar Creek, (2) Town Creek, (3) Pleasant Creek, (4) North Creek, (5) Birch Creek.

These are all natural channels.

(1) Cedar Creek is equally divided between us and Spring City, and its center forms the boundary line between us and Spring City on the south. It was first in use in 1865; the stream irrigates about 300 acres. There are about 800 acres of good land that could be brought under cultivation and irrigated from said channel if a sufficient water supply could be had.

(2) Twin Creek, first in use in 1860, irrigates about 600 acres of land, while there are 1,500 acres of good land which could be irrigated from said channel with sufficient water supply.

(3) Pleasant Creek, first in use in 1860, irrigates about 1,500 acres of land. There are about 1,500 acres of good land now lying idle which could be brought under cultivation and irrigated under said ditch.

(4) North Creek, first in use in 1860, irrigates about 400 acres of land. There are about 800 acres of good land under said ditch which could not be irrigated for want of water.

(5) Birch Creek. Said channel, or the center thereof, from the boundary line on the north, between Mount Pleasant and Fairview, gives half of the water to Fairview and half to Mount Pleasant. First in use in 1864. Irrigates 400 acres of land. Four hundred acres under said ditch not cultivated or irrigated for want of water.

The average depth of snow in the mountains in winter is about 6 feet. Irrigation season commences about May 15 and ends September 1.

For sandy soil 1 inch of water is required. For clay soil three-fourths of an inch will do. Land is irrigated once in three weeks. An irrigation stream used twenty-four hours for each 10 acres.

About 600 acres of grain is lost this year for want of water.

A reservoir site 5 miles north of Fairview is recommended; also Gooseberry Valley, 8 miles due east; it measures 1 by 1¼ miles. A dam 100 feet high and 400 feet long would raise the water over the little valley to the depth of 25 feet on an average. A tunnel of about 1 mile would have to be made; plenty of rocks and material near by for building dam. A stream, measuring about 200 inches in low water, empties in there besides the snow water from the mountains.

REPORT ON SEVIER COUNTY.

We have the honor of submitting, as per the governor's requests of July 8, 1889, and on other dates, requiring the county court of Sevier County, Territory of Utah, to place before you for investigation, and to be laid before the United States Senate committee, who are expected to visit Utah some time during the present month on matters connected with storage of cañon water for irrigation purposes, the following report:

In conformity to said request the county court convened on the 17th day of July, and the subject was fully discussed by the court and a committee was duly appointed, consisting of James M. Peterson, county surveyor, and W. H. Clark, for the purpose of making surveys, establishing heights, and cost of cañon dams and reservoirs, measuring streams, and such useful and general explorations as might lead to a fair understanding of the feasibility of said enterprise. The court, in connection with the appointment of said committee, secured the services of F. H. Newell, of the U. S. Geological Survey, who took an active part in the enterprise and proved a valuable man in aiding the committee in their efforts, possessing a thorough knowledge of the entire work.

It will be seen by the subjoined committee's report and the statistical reports of irrigation canals situated in this valley, together with their length, width, and cost, that they consist of eleven, with a running distance in the Sevier Valley of 104¼ miles, which flows over and irrigates about 18,000 acres of land, its fountain head being the Sevier River. In connection with these eleven irrigating canals supplied from the Sevier River, there are about 7,000 acres watered from different springs and creeks, making the total amount of 25,000 acres of land under the irrigation system at present.

In connection with this number of 25,000 acres we have a large body of arid land that with proper irrigation could be brought under a fair state of cultivation. An approximate estimate of the number of acres that could be thus cultivated amounts to over 100,000, lying and being situated in this county and known as the Sevier Valley. The majority of this land lies well for irrigation; quality of the soil good; will make beautiful *and productive* farms.

In submitting the foregoing and the statistical matter therewith connected, we would most respectfully ask that you would give that due consideration to a matter full of importance and intimately connected with the future growth and prosperity of not only this section of Territory but a great portion of the Western country. The suggestions of Engineer F. H. Newell, who has taken so much interest in the subject we refer to, as most feasible and proper, relating to the distribution of water for irrigation in this Territory similar to that system now existing in the State of Colorado.

L. B. KINNEY,
Probate Judge and ex officio County Judge.
ALBERT D. THURBER,
JAMES S. JENSEN,
B. H. GREENWOOD,
Selectmen.

In relation to the Wells Irrigation Canal taking water from the Sevier River, in the county of Sevier, are the following facts:

The length of canal is 4½ miles. The upper end or first section is 1½ miles long, 6 feet wide at bottom, and falls 1½ feet to the mile; the canal then narrows, and the next section is 1½ miles long, 5 feet wide at bottom, and falls 2½ feet per mile; next section is 1½ miles long, 4 feet wide at bottom, and falls 1½ feet per mile.

Cost of canal was $2,500. Of this cost $150 was in cash and the balance in labor at $2 per day of ten hours and $4 per day for man and team. The whole canal could now be built for contract price of $1,500.

Canal was begun in spring, 1872; finished spring, 1878; water first used from it in 1872.

This canal claims a right to .04½ water from Sevier River.

This canal is owned by an association, of which the legal name or title is "Wells Company Irrigation District," and the control is by trustees. Annual tax averages about 40 cents, which can be worked out at $2 per day of ten hours.

Land under canal, about 850 acres; actually irrigated, 530 acres. Of this amount now irrigated there are, in lucern or alfalfa, 160 acres. Other hay-making plants or grasses, 25 acres; small grains, etc., 315 acres; vegetables, etc., 25 acres; and orchards, 5 acres.

Irrigation begins March and ends in November.

Elsinore Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 9 miles; upper end or first section, 6 miles long, 8 feet wide at bottom, and falls 2⅝ feet per mile; the canal then narrows, and the next section is 3 miles long, 6 feet wide at bottom, and falls 3 feet per mile.

Cost of canal, $8,500; of this about $500 cash and the balance in labor at $1.50 per day of eight hours and $3 for man and team. Canal could now be built at contract price of $6,000.

The canal was begun in March, 1875; ended in April, 1877; water first used from it, 1875.

This canal claims a first right to .08 water from Sevier River.

Canal is owned by a corporation, of which the legal name is Elsinore Irrigation Company, and the control is by directors. The ownership is divided into 942 acres, of which all shares are now issued and in use. Par value of each acre is $9; actual selling value per share is about $9. Each share was intended to cover water to 1 acre. Owing to scarcity of water this year one share will give water for only three-fourths of an acre. Annual tax per acre averages about 30 cents, formerly from 50 to 75 cents, which can be worked out at $1.25 per day of nine hours.

Number of acres under ditch, 950; actually irrigated, 900 acres; of this amount now irrigated there are, in lucern or alfalfa, 50 acres; small grains, etc., 800 acres; vegetables, corn, gardens, etc., 50 acres; and in orchards, 30 acres.

Irrigation begins each year about April and ends about September 1.

The Richfield Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 17 miles. Upper end or first section is 11 miles long, 12 feet wide at bottom, and falls 5 feet to mile; canal then narrows and the next section is 4 miles long, 8 feet wide at bottom, and falls 5 feet per mile; next section is 2 miles long, 6 feet wide at bottom, and falls 3 feet per mile.

Cost of canal was $20,000. Of this about $500 cash, the balance in labor at $2 per day of ten hours, and $4 for man and team. Could be built at contract price of $10,000.

The canal was begun in the spring, 1865, and finished in spring, 1875. Water first used from it in 1865.

This canal claims a first right to .36½ water from river.

It is owned by a corporation legally named Richfield Irrigation Canal Company, *and the control is by* the directors.

Ownership is divided into 4,000 shares, of which 4,000 shares are now issued and in use. Par value of each share is $5; selling value $5. Each share was intended to cover water to 1¾ acres. Owing to scarcity of water present year, one share will give water for only three-quarters of an acre. Annual tax per share averages about $40, which can be worked out at $1.25 per day of eight hours.

Land under ditch, 7,500 acres; land actually irrigated, 5,000 acres; of this amount now irrigated there are in lucern or alfalfa, 500 acres; other hay-making grasses, 1,000 acres; small grains, etc., 3,390 acres; vegetables, etc., 100 acres; and in orchards, 10 acres.

Irrigation begins each year about April and ends about September 15.

Sevier Valley Canal, supplied from Sevier River, Sevier County. Length of canal, 15 miles; upper end or first section 15 miles long, 12 feet wide at bottom, and falls 4 feet to mile.

Cost of canal to date is $40,000. Of this $500 was cost and the balance in labor, at $2.50 per day of eight hours, and $5 per day for man and team.

The canal was begun in fall of 1884; not finished; water first used from it, 1888.

This canal claims secondary right to water from Sevier River. It is owned by a corporation legally named Sevier Valley Canal Company, and the control is by directors. The ownership is divided into 4,000 shares, of which 4,000 shares are now issued and in use. Par value of each share is $10, selling value, $5. Each share was intended to cover water to one-half an acre. Owing to scarcity of water present year one share will give water for only one-twentieth of an acre. Annual tax per share averages about $1, which can be worked out at $1.75 per day of eight hours. Number of acres under ditch, 6,000 acres; of this amount only 2,000 acres are actually watered during high water in Sevier River. Of this amount now irrigated there are in lucern or alfalfa, 50 acres; small grains, etc., 1,930 acres; vegetables, etc., 15 acres; orchards, 5 acres.

Irrigation begins March 15 and ends June 15 for want of water.

Thirteen miles of this (Sevier Valley Canal Company) was finished in 1888. It is located and leveled for a distance of 15 miles farther, and when finished will cover 6,000 acres in addition to what is now cultivated, making a total of 8,000 acres, depending on high water and contemplated reservoirs on the Sevier River.

Vermillion Irrigating and Extension Company, supplied from Sevier River, Sevier County. Length of canal is 18 miles. Upper end or first section, 9 miles long, 16 feet wide at bottom, and falls 2 feet to mile; canal then narrows and next section is 9 miles long, 12 feet wide at bottom, and falls 2½ feet per mile.

Cost of canal was $18,000, $1,000 cash, and the balance in labor at $2.25 per day of eight hours, and $4.50 per day for man and team. Could be built now at contract price for $8,000.

Canal was begun in spring, 1876; water first used from it, 1876.

This canal claims a primary right to water from Sevier River.

It is owned by a corporation legally named Vermillion Irrigation Canal Company, and the control is by directors. The ownership is divided into 1,016 shares; par value of each share, $10; selling value, about $10; each share was intended to represent water for 1 acre; owing to scarcity of water, present year, one share will give only water for one-half an acre. Annual tax per share averages about $1, which can be worked out at $1.50 per day of eight hours.

Number acres under ditch, 3,200 acres; actually irrigated, 1,200 acres. Of the amount now irrigated, there are in lucern or alfalfa, 100 acres; other hay-making plants, 350 acres; small grains, etc., 725 acres; orchards, 5 acres.

Irrigation begins about April 1 and ends about October 15.

The first 9 miles was finished in 1880; 12 feet wide in the bottom and enlarged in 1887 to 16 feet wide in the bottom.

The second section of 9 miles was begun in 1887 and finished and water conveyed through in spring of 1889.

The third section of 4 miles was begun in 1887, but part of it is unfinished.

The water in this canal is taken out of Sevier River near the city of Richfield, and when dry seasons, the water consists only of seepage from Richfield, Annabella, and Monroe irrigation districts, and from springs in or near the Sevier River.

Capital stock is 1,016 shares, at $10	$10,160
Assessment on shares for construction	7,840
Total	18,000

Isaacson ditch, supplied from Sevier River, Sevier County. Length of canal is 2 miles. Upper end or first section is 2 miles long, 4 feet wide at bottom, and falls 2½ feet to mile.

Total cost, $365—cash $25, and balance in labor at $2 per day of ten hours, and $4 per day for man and team. *Could now* be built at contract price for $250.

The canal was begun in 1871—finished spring, 1875. Water first used from it, 1871.

This canal claims a right to .00¼ water from Sevier River. It is owned by a private association, legally named Isaacson Irrigating Ditch, controlled by stockholders. Owing to scarcity of water, present year, one share will give water enough for only one-third of an acre. Annual tax per share averages about 15 cents, which can be worked out at $2 per day of ten hours.

Acres under ditch, 250; actually irrigated, 174; of this amount now irrigated there are in lucern or alfalfa, 24 acres. In small grains, (wheat, oats, etc.), 122 acres; in vegetables, corn, gardens, etc., 25 acres; orchards, 3 acres.

Irrigation begins each year about March and ends about November 1.

Joseph Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 5 miles. Upper end or first section is 2 miles long, 8 feet wide at bottom, and falls 5 feet to mile. Canal then narrows and next section is 3 miles long, 6 feet wide at bottom, and falls 6 feet per mile.

Cost of canal was $3,900—$100 cash, and balance in labor at $2 per day of ten hours, and $4 per day for man and team. The canal could now be built at contractor's price for $1,500.

Canal was begun in 1872, finished spring 1876; first water used, 1872.

This canal claims a first right to one-tenth of the water from Sevier River. It is owned by a corporation, legally named the Joseph Irrigating Company, and the control is by directors. Par value of each acre is $3.25. Each share was intended to represent water to 1 acre. Owing to scarcity of water, present year, one share will give water for only one-fifth of an acre. The annual tax per acre averages about 35 cents, which can be worked out at $2 per day of ten hours.

Number of acres under ditch, 1,400 acres; actually irrigated, 1,210. Of this amount now irrigated there are in lucern or alfalfa, 250 acres; in small grains, (wheat, oats, etc.), 850 acres; in vegetables, corn, gardens, etc., 75 acres; orchards, 40 acres.

Irrigation season begins about March and ends about November.

Monroe Irrigation Company's Canal, supplied from Sevier River, Sevier County. Length of canal is 8 miles. Upper end of first section, 4 miles long, 9 feet wide at bottom, and falls 4 feet per mile; canal then narrows and next section is 2 miles long, 7 feet wide at bottom, falls 4 feet per mile; next section is 2 miles long, 5 feet wide at bottom, and falls 4 feet per mile.

Cost of canal $6,900—$500 cash, and the balance in labor at $2 per day of ten hours, and $4 per day for man and team. Canal could now be built at contract price for $4,600.

The canal was begun in spring, 1865; finished spring, 1879; water first used from it in 1865.

This canal claims a first right to one-seventeenth part of the water from Sevier River. It is owned by association, legally named Monroe Irrigation Canal Company, and control is by directors. The ownership is divided into 2,300 acres, of which 2,300 acres is in use. Par value of each acre of water right is $4. Actual selling value per acre is about $4 per acre. The present year, owing to scarcity of water, one acre will give water for only two-thirds. The annual tax per acre averages 30 cents, which can be worked out at $1.50 per day of ten hours.

Acres under ditch, 2,500; actually irrigated, 2,000. Of this amount now irrigated there are in lucern or alfalfa 300 acres. Other hay-making plants, grasses, etc., 50 acres; in small grains (wheat, oats, etc.), 1,550 acres; in vegetables, corn, etc., 75 acres; orchards, 25 acres.

Irrigation season begins about April 1 and ends about October 1.

Brooklyn Canal, supplied from Sevier River, Sevier County. Length of canal 4 miles. Upper end or first section is two-thirds of a mile long, 9 feet wide at bottom, and falls 3 feet to a mile; the canal then narrows and next section is 3½ miles long, 7 feet wide at bottom, and falls 3 feet per mile.

Cost of canal $5,530—$280 cash, and the balance in labor at $2.50 per day of nine hours, and $5 per day for man and team. Canal could now be built, probably, at contract price for $2,750.

Canal was begun in spring, 1873; finished spring, 1878, and water was first used from it in 1873.

This canal claims a first right to a tenth part of the water from Sevier River. It is owned by a corporation, legally named Brooklyn Irrigation Canal Company, and the control is by trustees. The ownership is divided into 553 shares, of which 553 shares are issued and in use. The par value of each share is $10. Actual selling value is about $10. Each share was intended to represent water for each 2½ acres. The present year, owing to scarcity of water, one share will give water for only 1 acre. Annual tax per share averages about 50 cents, which can be worked out at $1.25 per day of nine hours.

Acres under ditch, 2,000; acres actually irrigated, 1,300. Of amount now irrigated *there are in lucern* or alfalfa, 700 acres; in small grains (wheat, oats, etc.), 500 acres; *vegetables, corn*, gardens, etc., 150 acres; orchards, 25 acres.

Irrigation begins each year about April 1 and ends about October 1.

This canal is a consolidation of a portion of Monroe Canal, all of Foreman ditch, all of Morsen Torensen ditch, and all of Brooklyn ditch.

Annabella Irrigation Canal, supplied from Sevier River, Sevier County. Length of canal, 7 miles. Upper end or first section, 6 miles long, 7 feet wide at bottom, and falls 2½ feet to mile; the canal then narrows, and next section is 1 mile long, 5 feet wide at bottom, and falls 2½ feet per mile.

Cost of canal $7,500—$200 cash, and balance in labor at $2 per day of eight hours, and $4 per day for man and team. Canal could now be built for contract price, $4,000.

The canal was begun in spring, 1872, finished spring, 1876. Water was first used from it the spring of 1872.

This canal claims a first right to a one-ninth part of the water from Sevier River. It is owned by a corporation, legally named the Annabella Irrigation Canal Company, and the control is by directors. The ownership is divided into 700 shares, of which 700 shares are now issued and in use. The par value of each share is $10; actual selling value, per share, about $6. Each share was intended to represent water for each 2 acres. The present year, owing to the scarcity of water, one share will give water for only 1 acre. The annual tax per share averages about 50 cents, which can be worked out at $1 per day of eight hours.

Acres under ditch, 3,000; acres actually irrigated, 1,305. Of amount now irrigated there are in lucern or alfalfa, 200 acres; in other hay-making plants or grasses, 600 acres; in small grains (wheat, oats, etc.), 475 acres; in vegetables, corn, gardens, etc., 25 acres; orchards, 5 acres.

Irrigation begins each year about April 1 and ends about October 1.

Rocky Ford Canal, supplied from Sevier River, Sevier County. Length of canal, 15 miles. Upper end or first section is 11 miles long, 12 feet wide at bottom, and falls 2½ feet to mile. Canal then narrows and the next section is 4 miles long, 4 feet wide at bottom, and falls 2½ feet per mile.

Cost of canal was $4,000, $200 cash and balance in labor at $1.50 per day of eight hours, and $3 per day for man and team. Whole canal could probably be built now for contract price of $3,000.

Canal was begun in spring of 1875; finished, spring, 1884, and water was first used from it in 1875.

This canal claims a primary right to a tenth part of the water from Sevier River. It is owned by a corporation, legally named the Rocky Ford Canal Irrigation Company, and the control is by directors, who appoint water-master. The ownership is divided into 400 shares, of which 400 shares are now issued and in use. The par value of each share is $10; actual selling value per share is about $10. Each share was intended to represent the water for each 10 acres. The present year, owing to scarcity of water, one share will give water for only 5 acres. Annual tax per share averages about $1, which can be worked out at $1.50 per day of eight hours.

Acres under ditch, 6,000; acres actually irrigated, 2,000. Of amount now irrigated there are in lucern or alfalfa, 300 acres; in other hay-making plants or grasses, 200 acres; in small grains (wheat, oats, etc.), 1,325 acres; in vegetables, corn, gardens, etc., 150 acres; orchards, 25 acres.

Irrigation begins each year about May 1, and ends about end of September.

Water for this canal is taken from the Sevier River, about eleven miles northeast of Richfield. In dry seasons this consists only of seepage from the Sevier River, also water from the Cave River and from springs.

In accordance with the appointment of July 17, 1889, we also proceeded on our way of investigating the rights of the different irrigation companies in this county to water from Sevier River. We visited the following companies and got reports from Joseph Wells, Isaacson, Sevier Valley, Elsinore, Richfield, Monroe, and Annabella Canals; also a report from the Vermillion Canal Company.

On the morning of July 24, in company with Mr. F. H. Newell, United States engineer, we proceeded up the Sevier River to prospect for suitable places to build reservoirs; the first day we drove into the East Fork Cañon.

On the 25th we examined the swamp and meadow on Otter Creek from its junction with the East Fork and up east and northeast. Here we found that a dam 170 feet long will be required; the swamp is about 1 mile long; above is a meadow about 5 miles long; the entire valley here can be covered one-half mile wide by a dam 5 feet high; we think all the ranches here could be bought for $15,000 to $18,000.

On the 26th Mr. Isaac J. Riddle went with us up the East Fork from the junction of Otter Creek, and at the lower end of Plateau Valley we found that a dam 16 feet high would back the water of the East Fork at least 1½ miles up the valley south and one-half mile wide, with two bends running back some considerable distance behind some lava points; length of dam about 180 feet; material handy. From here we went up to Kanarra Ranche *to look at* a site which we considered as very fair but

not of practical value for this county; we also went up Clay Creek, where a small lake might be reservoired, but not to any direct advantage to us.

On our way back we examined the head of Sevier Cañon, below Marysvale, but owing to the limited time at our disposal we could not make thorough examination of this place, but estimated that a dam 10 feet high would back the water of Sevier River 2 miles up to the lower end of Marysvale Valley; average width one-fourth of a mile. We also prospected in Clear Creek Cañon and some of its tributaries, but in our limited time did not find any suitable sites in the Dry or Fish Creek branches; came on down and measured the Sevier River above Joseph Canal Dam and found a flow of 70 cubic feet per second. We would recommend a further examination of the branches of Clear Creek Cañon.

The foregoing is respectfully submitted.

JAS. M. PETERSON,
WM. H. CLARK,
Committee.

To the Judge and members of the county court of Sevier County.

PARTIAL REPORT ON TOOELE COUNTY.

The several sources of supply are very much scattered and far apart, and in dry seasons, through seepage and evaporation, fail to reach the proper channel, which difficulty could be obviated by the use of pipes or flumes. The inhabitants of this county would receive more direct and immediate benefit from the construction of flumes or pipe conduits to convey water lost by seepage in the mountains than from any other means of conservation or storage, as the main difficulty is in conveying the water over the porous soil to the lands suitable for agriculture.

The amount of arable land in Tooele Valley is 100,000 acres, of which 5 per cent. is under cultivation. The amount of arable land in Rush Valley, Tooele County, is 200,000 acres, of which 1 per cent. is under cultivation. The amount of arable land in Skull Valley, Tooele County, is 300,000 acres, of which one-half of 1 per cent. is cultivated.

The total area of Tooele County is about 5,000 square miles, containing a population of about 5,000 inhabitants. In this area is to be found a very large portion of the Great American Desert, and is therefore drier than most other counties, and its citizens have a harder struggle for existence and to obtain a livelihood than those of more favorable localities.

A great tax is annually levied upon the people for the construction and maintenance of a large system of irrigation canals and ditches in the different irrigation districts.

It is recommended that a geological survey be officially made by the General Government of the several irrigation districts of Tooele County, and a sufficient appropriation to cover the expense of piping and collecting the water from the various sources of supply.

CHARLES A. HERMAN,
HUGH S. GOWANS,
Committee.

Canals of Tooele County.

District and stream, cañon, or source.	Miners' inches with 6-inch pressure.	Cultivated.	Snow-fall.	Miles of conduits or flumes needed.	Average elevation.	What 1 miners' inch will water.
Tooele City:		*Acres.*	*Feet.*	*M. ch.*	*Feet.*	*Acres.*
Settlement	470	1,558	3	5 66	.....	1½
Middle	363			4 10	5,000	1½
Grantsville:						
N. Willow	500	1,000	3	5 23		2
S. Willow	400	1,000	3	5	4,350	2
Box Alder	100			3 50		2
Lake View:						
Pine Cañon	125	250	3	2	5,000	1½
Vernon District:						
Big Creek	375	750	2½	.....	5,500	2
Stockton:						
Soldier Cañon	100	150	3	2	5,200	1½
Ophir:						
East Creek	170	350	3	3	5,300	2
St. Johns:						
Clover Creek	175	500	2½	4	5,100	2
Deep Creek:						
15-M. Creek	28	57	3			2
Middle Creek	120	235	3			2
Main Creek	90	175	3	.....	4,400	2
East Creek	75	150	3			2
West Creek	40	75	3			2
		6,250				

District and stream, cañon, or source.	Volume that conduits or flumes would increase water.	Duration of irrigation season.	Nature of soil.	Acres to cubic foot.	Remarks.
Tooele City:		*Months.*			
Settlement	Add ½	.....	Sandy	60	Lucern watered in winter months.
Middle	Double	10	Loam	60	Insures one good crop.
Grantsville:					
N. Willow	Double	12	Clay	80	Subject to cloud bursts.
S. Willow	Double	12	do		Do.
Box Alder	Double	12	do		Good locations for reservoirs.
Lake View:					
Pine Cañon	Add ½	10	Sandy loam.		Do.
Vernon District:					
Big Creek		7	Loam clay.		Do.
Stockton:					
Soldier Cañon	Double	7	Clay loam.		
Ophir:					
East Creek	Double	7	Light clay.		
St. Johns:					
Clover Creek	Add ½	7	Clayey		Do.
Deep Creek:					
15-M. Creek		7	Clay		Do.
Middle Creek		7	Loam		Do.
Main Creek		7	do		Do.
East Creek		7	do		Do.
West Creek		7	do		Do.

REPORT ON UINTAH COUNTY.

There was very little irrigation in Uintah County prior to 1878. Pardon Dods, the first settler, used the first water for irrigation about the year 1874. In the spring of 1878 there were scattered along Ashley Creek about a dozen ranches, some with a few acres of oats and small gardens, but depending mostly on stock-raising and trapping for a living. Among these were R. Veltman, Pardon Dods, John Kelly, R. Snyder, A. Taylor, T. Taylor, A. Beatie, W. S. Powell, John Fairchild, George Thorn, sr., James Reed, William Brit, McFarley and McNight, Charles Lyons, and William Graham.

Jeremiah Hatch, sr., David Johnston, Joseph H. Black, Alva Hatch, A. Johnston, and William Clark settled near the present site of Vernal in April and May. After making several trips for their families' supplies, etc., they began taking out the ditch now known as the Central Canal. This company was soon strengthened by others, among whom were James Hacking, Nelse and George Mercley, Alford and S. Johnson. The ditch was ready for use the next spring, and good crops were raised.

At this time there were more settlers along the creek than on the bench. About one fourth the water was taken on the bench and the remainder run down the creek. This was not sufficient to reach the lower settlers, and at this early date many lost their crops. It was soon discovered that it took less water to run through the Canal than through the creek-bed. At the present time the water is divided at the mouth of the cañon into three equal parts, one running down each of the canals and the other down the creek. Springs have broken out in many places along the foot of the bench and large streams of waste water are continually flowing down the waste ditches of the creek, but this will not reach the lower settlers during the month of July, and many of them annually lose their crops.

The land owners of Ashley Valley have organized into a company, termed the Ashley Consolidated Irrigation Company, for the purpose of constructing reservoirs, increasing the flow of Ashley Fork, and building weirs at the mouth of the cañon to more evenly divide the water. The result is seven fine reservoirs with an average depth of 5 feet and containing 100 acres. Each reservoir has a gate that can be raised by one man. There are several other lakes that will be converted into reservoirs in the near future.

Dry Fork or the West Fork of Ashley, a stream nearly as large as Ashley, sinks in the rocks of Dry Fork Cañon. This could be brought out in a flume 6 miles long. Besides there are several very fine reservoir sites on this stream.

The average depth of snow in the mountains is about 6 feet, though on the highest mountains it is much deeper.

In the south part of Ashley Valley is a tract of land of nearly 9,000 acres that could be used with but little trouble with an increase of water. On the east side is another fully as large. On Green River is another, containing about 3,500 acres, all of which would make good homes by a little care and means.

Hay land, pastures, orchards, and farming lands are included in the acres irrigated and the farming lands are again reported as acres cultivated. The calculations are made from the size of our water boxes—21 square inches—flowing at the rate of about 7 feet per second, from the 1st of May till the 1st of July; if properly handled will produce 40 acres of small grain on the sandy soil of the benches. The clay soil bakes quickly, and must have water every few days till the crops are high enough to shade the ground. Grass and lucern do well on clay soil with about the same water as on sandy soil. Corn can be produced on clay soil with the same water as on sandy soil by an extra amount of cultivating. Wild hay and pasture require but very little after high water, but lucern must have water during the entire season to produce three crops, though any or all the arable land in the county could be made to produce one good crop of lucern each year with the high water, of which there is a very great surplus from the 1st of May until the 25th of June, when it falls very suddenly about 80 per cent. By summer fallowing the land and putting in fall wheat, or waiting till spring and putting in early spring grain, good crops can be raised from the high water. By this means many thousands of acres of land which now belongs to the public domain could be made to produce extra good crops every other year.

JAMES HACKING,
JOHN GLEMO,
Special Committee to Collect and Compile Irrigation Information.

Irrigation canals and streams in Uintah County.

No. I.

Name of canal.	Date when built.	Streams from which water is diverted.
Upper Canal	1879	Ashley Fork.
Central	1876	Do.
Downenor Brooks	1878	Do.
Steinaker	1888	Do.
Rockpoint	1880	Do.
Dodds'	.....	Do.
Chadwick	1879	Do.
Union	1884	Do.
McKee	1879	Do.
Powell & Kabell	1880	Do.
Powell & Kabell, south	1878	Do.
Fairchild	1878	Spring Fork.
Chivers & Co	1889	Ashley Fork.
Burton	1875	South Fork Ashley.
Dillman	1882	Do.
Taylor	1881	Do.
Tucker	1853	Do.
Colton	1880	Do.
Snyder	1876	North Fork Ashley.
Dry Fork, north	1878	Dry Fork.
Dry Fork, south	1884	Do.
Burns' Bench	1888	Brush Creek.
Murry	1888	Do.
Burton	1879	Do.
Veltman & Co	1883	Waste ditch No. 3.

Acres irrigated and duty on water in Uintah County.

No. II.

Name of canal.	Irrigated.	Cultivated.	Could be cultivated by an increase of water.	Date of irrigating season.	Elevation above the sea.
	Acres.	*Acres.*	*Acres.*		*Feet.*
Upper Canal	.....	.....	.....	Apr. 1 to Dec. 1	4,800
Central	4,440	3,560	7,400	....do	4,600
Downenor Brooks	.....	.....	400	Apr. 1 to Oct. 1	.....
Steinaker	85	80	1,000	....do	4,800
Rockpoint	527	427	1,100	Apr. 1 to Dec. 1	4,800
Dodds'	.....	.....	.....	....do	.....
Chadwick	300	72	600	....do	.....
Union	130	57	1,000	Apr. 1 to July 1	4,400
McKee	320	285	.....	Apr. 1 to Nov. 1	.....
Powell & Kabell	570	385	50,000	Apr. 1 to Oct. 15	4,400
Powell & Kabell, south	220	(*)	(*)	...do	.....
Fairchild	50	12	15	Mar. 15 to Oct. 1	.....
Chivers & Co	36	30	267	May 1 to Nov. 15	.....
Burton	250	110	960	Apr. 1 to Oct. 1	.....
Dillman	38	31	80	....do	.....
Taylor	84	31	324	....do	.....
Tucker	52	25	110	....do	.....
Colton	60	20	80	....do	.....
Snyder	245	.....	295	Apr. 1 to Dec. 1	.....
Dry Fork, north ditch	425	.....	425	May 10 to Nov. 1	5,000
Dry Fork, south ditch	75	.....	75	....do	5,000
Burns' Bench	620	.....	2,000	....do	.....
Murry	340	.....	.....	....do	.....
Veltman & Co	65	35	198	May 1 to Nov. 15	4,400

Acres irrigated and duty on water in Uintah County—Continued.

Name of canal.	Amount of water required to irrigate an acre.										Lost by scarcity of water in 1888–'89.		
	Sandy soil.					Clayey or alkaline.							
	Small grain.	Lucern grass.	Roots.	Corn.	Orchards.	Small grain.	Lucern grass, etc.	Roots.	Corn.	Orchards.	Small grain.	Grass.	Corn.
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Acs*	*Acs*	*Acs*
Upper Canal	22, 750	25, 500	28, 436	11, 000	11, 000	44, 700	255, 000	50, 000	11, 000	11, 000	----	----	----
Central	22, 750	25, 500	28, 436	11, 000	11, 000	44, 700	255, 000	50, 000	11, 000	11, 000	300	300	100
Downenor Brooks	22, 756	25, 500	28, 436	11, 000	11, 000	....	255, 500	50, 000	11, 000	11, 000	----	----	....
Steinaker	22, 750	25, 500	28, 436	11, 000	11, 000	44, 700	255, 500	50, 000	11, 000	11, 000	15	---	....
Rockpoint	20, 750	22, 000	25, 000	9, 000	9, 000	22, 000	2, 550	22, 000	10, 000	11, 000	25	----	....
Dodds'	20, 750	22, 000	25, 000	9, 000	9, 000	22, 000	2, 550	22, 000	10, 000	11, 000	--	----	....
Chadwick	22, 750	25, 000	28, 436	11, 000	11, 000	22, 750	2, 550	25, 000	11, 000	11, 000	--	----	....
Union	------	------	------	------	------	44, 700	25, 500	50, 000	11, 000	11, 000	18	30	20
McKee	22, 750	25, 500	------	------	------	44, 700	25, 500	------	------	------	55	30	20
Powell & Kabell	------	------	------	------	------	------	------	------	------	------	20	11½	....
Powell & Kabell, south	------	------	------	------	------	------	------	------	------	------	----	----	....
Fairchild	------	------	------	------	------	------	------	------	------	------	----	----	....
Chivers & Co	------	------	------	------	------	------	------	------	------	------	23	----	3
Burton	22, 750	15, 000	25, 000	11, 000	11, 000	------	------	------	------	------	--	----	....
Dillman	------	25, 000	25, 000	11, 000	11, 000	------	------	------	------	------	---	----	....
Taylor	20, 000	22, 000	25, 000	9, 000	9, 000	------	------	------	------	------	---	----	....
Tucker	22, 000	22, 000	25, 000	9, 000	9, 000	------	------	------	------	------	--	----	....
Colton	22, 750	22, 500	28, 436	11, 000	11, 000	------	------	------	------	------	---	----	....
Synder	------	9, 000	------	------	------	------	------	------	------	------	---	----	....

* Pasture.

REPORT ON UTAH COUNTY.

The county committee find the average depth of snow in the mountains in the winter 4 feet.

The number of cubic feet of water necessary to produce 1 acre of crops, 40,000.

Field land should be watered every fifteen days and orchards once a week. All the water is owned by priority of appropriation and is not of record.

During the winter and spring months there is water goes to waste that could be stored in reservoirs on the east side of the valley, sufficient to water all the land on the east side. Artesian water could be had for all the land on the west side of the valley. The land is owned, however, in 5, 10, and 20 acre lots by people who are unable to build reservoirs or drive experimental wells.

Table showing acres of land cultivated, acres that could be cultivated with increase of water, and acres of crops lost this year for want of water.

Name of precinct.	Natural streams.	When appropriated.	Canals in each precinct.	Cultivated.	Could be cultivated with an increase of the water supply.	Water per second.	Crops lost this year for want of water.
			Miles.	*Acres.*	*Acres.*	*Cu. ft.*	*Acres.*
Cedar Forte	North Cañon Creek and Fort Springs.	1854	18	500	76,000	12	400
Fairfield	Fairfield Springs	1855	2	300	2,000	3	None.
Goshen	Salt Creeks	1852–1878	18	1,500	60,000	15	500
Lehi	Dry Creek and Spring Creeks	1851	30	7,800	5,500	20	3,334
Alpine	Dry Creek Springs	1850	25	1,400	1,300	15	1,300
American Fork City	American Fork River, Battle Creek, and Provo River.	1851	25	4,291	7,050	21	3,840
Pleasant Grove City	Amreican Fork River and Grove Creek.	1852	20	6,500	3,700	21	2,000
Santaquin City	Summit Creek	1852	15	500	7,000	9	800
Spring Lake City	Spring Lake	1851	4	300	600	3	100
Payson City	Spring Creek and Petutnut and Salem Canal.	1851–1867	50	2,000	19,000	21	3,000
Spanish Fork	Spanish Fork River	1854–1889	114	1,192	14,880	24	5,313
Springville	Hobble Creek and Spring Creek.	1851–1880	95	5,025	7,000	17	1,700
Provo City	Provo River and Rock Cañon Creek.	1871	175	16,000	9,000	95	800
Benjamin	Spanish Fork River	1876	20	5,000	6,526	12	2,500
Lake Shore	....do....	1866	25	3,840	3,840	8	2,000
Salem	Spanish Fork River and Springs.	1869	26	2,250	2,200	12	1,390
			662	69,126	225,540	308	28,985

IRRIGATION AT SPRINGVILLE, UTAH COUNTY.

A series of mass-meetings held in Springville on the 12th, 27th, and 31st of May, 1889, also one on the 17th of June, consisting of citizens of what is known as Mapleton Ward, which embaces an area of about 9 square miles, and is the southern and eastern portion of Springville corporate limits, resulted in the appointment of John Luckett chairman of a committee to represent to the Senate Committee on Irrigation in the Territory the necessity of irrigation to the aforesaid portion of Springville city, Mapleton Ward.

The object of this communication is to show through said committee the result of the labors of a previous committee appointed by said series of mass-meetings to ascertain if the waters of Strawberry Creek, in Strawberry Valley, and lying in the Indian reservation, could be brought into Springville through Spanish Fork cañon for irrigating purposes.

The last-named committee, or committee of investigation, in Strawberry reported as follows to the mass-meeting held June 17, 1889:

That the water of Strawberry can be taken into Spanish Fork River by constructing a ditch 20 miles in length, with a tunnel through the dividing summit 600 feet long. The amount of water thus obtained will exceed the water running in Hobble Creek, or five or six good irrigating streams.

Nearly the whole of the said southern and eastern portion of Springville is now without water in consequence of the decrease of Hobble Creek, the older water claims taking precedence, and leaving Mapleton people with their grain, fruit, and shade trees already perished.

Our hopes are that through Government means something may be done for our relief in the near future. By order of the mass-meeting.

JOHN LUCKETT, *Chairman.*
O. B. HUNTINGTON, *Secretary.*

REPORT ON PLEASANT GROVE, UTAH COUNTY, IRRIGATION WORKS.

Joseph W. Ash, secretary of the North Union Irrigation Canal, reports:

Names of officers: A. B. Walker, president; Robert Thorne, T. C. Banks, William Kirk, William *M. Frampton, A. G.* Johnson, and James Backhouse, trustees, all of *Pleasant Grove City.*

The canal was first used in connection with the Provo Bench Canal and Irrigation Company's canal in 1868, and flows north from Provo River, at the mouth of Provo Cañon. It irrigates about 1,000 acres; number of acres that could be irrigated, about 2,000. Time of irrigation from May 1 to October 1. Water used about eight hours to the acre every fourteen days. The right of water is first-class.

Length of canal, 5 miles; situated on Provo Bench from mouth of Provo Cañon to Pleasant Grove City.

About one-half of the acreage irrigated is devoted to lucerne, and nearly one-half is lost through drought this season.

REPORT ON WEBER COUNTY.

The total number of acres situated under the canals and ditches of this county approximates 117,600 acres, 100,000 acres in Salt Lake Valley and 17,600 acres in Ogden Valley. Of the above about 25 per cent. may be said to be fully irrigated.

The following is a list of the principal streams in the county, with the approximate volume of water in each, in cubic feet per second, as measured by me from the 3d to the 9th of July, 1889. Each stream was measured above the points where irrigating canals are taken out:

Name of stream.	Cubic feet per second.	Remarks.
Burch Creek	0.83	At mouth of cañon.
Buse Creek	0.12	Do.
Bennett Creek	0.79	Do.
Cold Creek	0.33	Do.
Alder Creek	0.39	Near residence of Mrs. Johns.
Middle Fork	0.83	At mouth of cañon.
North Fork	48.00	Near Southwick's mill.
North Ogden Cañon Creek	0.3	At mouth of cañon.
Ogden River	97.0	Do.
Rice Creek	1.7	Near head of stream.
South Fork River	64.0	At mouth of cañon.
Strong's Cañon Creek	0.4	Do.
Taylor's Cañon Creek	0.4	Do.
Water Fall Creek	0.04	Do.
Uintah Creek	0.53	Do.
Weber River	106.00	Do.
Wolf Creek	4.00	Do.

The total volume of water indicated above is increased 20 per cent. from springs and artesian wells.

List of the canals and ditches in Weber county.

Names of canals and ditches.	Stream from which diverted.	Remarks.
Burch Creek Canal	Burch Creek..	
Eden Canal	Woolf Creek.	
Ferrins ditch	Spring Creek.	Small ditch.
Frank Law's ditch	Middle Fork..	
Hooper Canal	Weber River.	Used also in Davis County.
Huntsville Canal	South Fork...	
Harrisville Canal	Ogden River..	
Hall's ditch	South Fork...	Small ditch.
Hall's J. Ditch	Weber River.	
Langsdorf's ditch	South Fork...	
Lynne Canal	Ogden River..	
Mountain Canal	South Fork...	
Montgomery and Roylance ditch	Rice Creek...	
North Ogden Canal	Ogden River..	
Ogden City Canal	Weber River.	
Ogden Bench Canal	Ogden River..	
Plain City Canal	....do	
River Dale Canal	Weber River.	
Riries ditch	.....	Small springs.
Stimpson and Dyke's ditch	Weber River.	
Salt Creek Canal	....do	Not completed situate near Plain City.
Uintah Canal	....do	
Weber and Davis County Canal	....do	Only part used in Weber County.
Wilson Canal	....do	
Jenkins ditch	....do	

A number of available sites for reservoirs may be found in the hills around Ogden Valley to the south and east of Huntsville. Also at the head of Wheeler's Creek in Ogden Cañon, there exists a most admirable site, which could be made to contain at least 300,000 cubic yards of water.

The mean elevation of Salt Lake Valley in Weber County, is approximately 4,315 feet; that of Ogden Valley approximates 5,000 feet above sea level.

The average depth of snow in the mountains during the winter, is 2 feet.

WASHINGTON JENKINS,
County Surveyor.

Water rights from running streams in Weber County, acres irrigated, the sources.

TABLE NO. I.

Name of stream.	Used to irrigate.	Remarks.
	Acres.	
Burch Creek	77.4	
Do	77.4	
Do	77.4	
Do	77.4	
Do	77.4	The first certificate of water right issued is dated December 1, 1880, and the last is dated July 19, 1883.
Do	.....	
Do	79.5	
Do	.....	
Do	.....	
Do	76	
Do	.....	
The Mountain Stream	4	Source in mountains northeast of Uintah.
Do	22	Do.
Do	2.25	Do.
The Mountain Stream and Weber River	26.76	Do.
Do	51.49	Do.
Do	1	Source near Uintah.
Do	8.44	
Weber River	8.44	
Do	23	
Do	16.89	
Mountain Stream	16.89	
Do	49.36	
Mountain Stream and Weber River	49.36	
Do	18.5	
Do	57	
Do	31	
Do	52.95	
Do	18.72	
Do	21	
Do	2.5	
Do	18.45	
Mile Creek	65	Both of Slaterville.
Mountain, Quaking Asp, and Dry Springs	40	Source near Uintah.
Dry Cañon Springs and Four Mile Creek	125	
Do	70	
Burch Creek	80	
Do	155	
Bingham Fort Meadow Springs	155	
Four Mile Creek	30	
"The Mountain Water"	4.46	Near North Ogden.
Strong's Cañon Creek	150	Near Ogden.
Strong's Cañon Creek, surplus ditch from	12.22	Do.
Mud Creek	19.06	Near North Ogden.
Do	20.85	Do.
Do	22.55	Do.
Do	.....	Do.
Do	43	
Do	160	
Ditch from Burch Creek	320	
Cold water Creek	17	Source near North Ogden
Burch Creek	15	
Do	260	
Surplus ditch from Strong's Cañon Creek	176.41	
Five Mile Creek	151	Source near Harrisville.
Surplus of Bench Creek during winter	80	
Cold Water Creek surplus	8	Source near North Ogden.
Do	10	Do.
Do	43	Do.
Do	16	Do.

Water rights from running streams in Weber County, etc.—Continued.

Name of stream.	Used to irrigate.	Remarks.
	Acres.	
Surplus of Chatelain Ditch and Strong's Cañon Creek.	14	Source near North Ogden.
Canfield Creek	2.5	Source near Ogden.
Do	7	Do.
Strong's Cañon Creek	2.5	
Do	3.6	
Canfield Creek	6	
Do	2	
Strong's Cañon Creek	4	
Mountain Stream and North Division of Rice Creek, source near North Ogden.	100	During January, February, March, April, May, October, November, and December of each year.
Taylor's Cañon Stream	5	Source east of Ogden.
Weber River, a lake and spring	12	
Strong's Cañon Creek	4	
The "Mountain Water"	135	Source in Isiah Cañon near North Ogden
Strong's Cañon Creek	17.20	
Dixon Creek		
Weber River	35.40	
Mill Creek	8	Source Ogden River.
Do	20	Do.
Do	22	Do.
Do	27	Do.
Mill Creek and Tarr's factory race	40	Do.
Weber River		
Weber River flowing through Taylor's mill race.	171	
North Fork of Ogden River and Woolf Creek Cañon Stream.	4,000	
Mill Creek	101.92	
Weber River	120	
Burch Creek	9	
Weber River	(*)	
Mill Creek	400	Source Ogden River.
Ogden River	500	
Brown Creek		
Mill Creek	383	
Do	5,760	
Weber River	5,760	
Ogden River	5,760	
Strong's Cañon Creek	115	
The Brown section	38	Source in Mill Creek.
Strong's Cañon Creek	13.16	
Berrett's Cañon Creek	160	Source near North Ogden.
Strong's Cañon Creek	30	Source near Ogden.
Spring Creek	240	
Herd House Creek	240	Source Ogden Valley.
North Fork of Ogden River.	240	
Ogden River	(†)	
Weber River	240	
Canfield Creek and certain springs	47.05	
Strong's Cañon Creek	12	
Canfield's Creek	20	
North Fork of Ogden River	120	
Spring Creek	160	Do.
Brown Creek	15.85	Source Ogden River.
Paine Cañon and certain spring therein	300	Source near North Ogden.
Lindsay Ditch, including waters of Thimbleberry Creek, Balsam Grove Creek, and the North Fork of Ogden River.	240	Source in Eden.
Mountain Water and Grant Springs	125	Source near North Ogden
Lindsay Ditch, including waters of Thimbleberry Creek, Balsam Grove Creek, and the North Fork of Ogden River.	280	
Taylor's Cañon	5	East of Ogden.
Do	80	Do.
Do	15	Do.
Do	5	Do.
Wester Creek and a certain spring	80	Source Ogden Valley.
Coldwater Cañon Creek and a certain spring; also all springs in Coon Cañon.	80	Source near North Ogden
Cole Cañon Creek and Thimbleberry Creek	150	
Mice Creek	99	
One Horse Cañon	66	Do.

* A larger section.
† All owned by shareholders.

Water rights from running streams in Weber County, etc.—Continued.

Name of stream.	Used to irrigate.	Remarks.
	Acres.	
Gertisoa Cañon Creek and certain springs	259.76	Source, the Ogden Valley.
Middle Fork Cañon Creek	25.79	Headwaters of Ogden River.
Do	25	
Mill Creek	21	
Weber River	23	
Do	20.60	
Do	33.46	
Do	28.65	
The old Brown and Cardon Canal	83.89	Source, the Ogden River through Mill Creek.
The old Tracy water ditch	84	Do.
Ogden River	584	
Mill Creek, flowing in Mound Fort section	48.875	Source Ogden River.
Weber River	1,113	
Four Mile Creek	.....	Source Weber River, below confluence.
Mill Creek	3.90	
Bennett Creek	480	Source near Huntsville.
Hawkins Creek	200	Do.
Mill Creek	5	Source Ogden River.
Coldwater stream and a certain spring	31	Source near North Ogden.
Rice Creek and Ogden Hole Cañon waters	5	Do.
Mill Creek	139.27	Source Ogden River.
Ben's Cañon Creek, surplus, ditch of Burch Creek and a spring.	295.82	Source near Ogden, to the south.
Do	82.03	Do.
A ditch from Strong's Cañon	82.03	Do.
Canfield Creek and Strong's Cañon Creek	10	Do.
Rice Creek and Ogden Hole Cañon stream	12	
Weber River	24	
Alder Creek Missouri Creek	.....	Certain lands near North Ogden.
Beach Creek	15	
South Spring Creek	15	Source in Ogden Valley.
Spring Creek	25	Do.
Spring Hollow	15	Do.
Broom section	37	Source, in Ogden River by Mill Creek.
Mill Creek	20	Do.
Wester Creek	120	Source near North Ogden.
Spring Creek	.....	Do.
Herd House Creek	80	Do.
Spring and Chicken Creek	280	
Weber River	100	
Strawberry Springs and Cole Creek, alias Pine Cañon, alias Herd-House Creek.	400	
Mill Creek	7	
Rice Creek, or Five Mile Creek Six Mile Creek	71.80	
Chicken Creek and a certain spring	80	Source near Eden.
The Mountain stream	40	Source near Uintah.
Ogden River and Mill Creek	14	
Burch Creek	80	
Cold Water Creek	7.25	Source near Ogden.
Mill Creek, flowing through Bingham Fort section.	25	
Mill Creek	1,000	
A certain stream in sec. 4 T, 5 N., R. 1 W	.....	
Coldwater stream	.....	Do.
South Fork of Ogden River Middle Fork of Ogden River	3,050	
Canfield Creek	1	
Lindsay and Shaw Ditch	280	Source, North Fork of Ogden River.
Waterfall and Strong's Cañon of Canfield Creek	25	Source near Ogden.
Do	5	Do.
South Fork of Ogden River	30	
Weber River	23	
Do	477	

Water rights to springs in Weber County.

No. II.

Name of spring.	Used to irrigate.	Remarks.
	Acres.	
Stone Springs	20	Situate near Uintah.
Willow Springs	80	Situate near North Ogden.
Hooper Springs	(*)	Situate near Hooper.
Certain springs having source in Jonathan Campbell's farm at North Ogden.	77	Situate near North Ogden.
Grant Springs	20	Do.
Garner's Springs	160.21	Do.
Cat Claim Springs	6.33+	Do.
A certain spring situate on Sixth street, Ogden.	2	Situate in Ogden.
Two certain springs in Taylor's Cañon	10	Situate east of Ogden.
Fisher's Spring	300	Situate in Eden.
Springs in One-Horse Cañon	(†)	Situate near North Ogden.
Springs in sec. 18, T. 7 N., R. 1 W	160	Do.
Springs having source in Jonathan Campbell and A. Chadwick's farms at North Ogden	43.93	
Do	113.75	
Three springs having source in "White Bank," near North Ogden.	100	
Six springs known as Alder Springs, flowing from "Pole-Patch farms."	.....	Do.
Three springs, situate on sections 18, 19, and 20, T. 7 N., and R. 1 W.	.....	Do.
Springs in sec. 9, T. 5 N., R. 1 W.	100	Situate near Ogden, to the south.
Four springs, situate on Henry Barber's farm in sec. 33, T. 7 N., R 1 W.	4	Situate near North Ogden.
Springs which form Alder Creek, and all waters flowing from mouth of Big Hollow.	50	
Certain springs in sec. 18, T. 6 N., R. 2 E	8	
"Coffin's Springs" and certain other springs situated along the South Bench of Huntsville.	12	
Several springs in sec. 8, T. 6 N., R. 2 E., forming what is called Perry Creek.	14	Situate near Huntsville.
Spring, situated in what has been heretofore known as Bunker's Hollow, in or near Ogden City.	6.60	
Coffin's Springs, having their source in sec. 18, T. 6 N., R. 2 E.	.....	Also to run machinery and fish-pond.
Certain springs arising in sec. 18, T. 6 N., R. 2 E, which form below David W. Garner's.	4 to 5	

*Part of sec. 8, T. 5 N., R. 2 W. †Part of secs. 3 and 4, T. 6 N., R. 1 W.

REPORT ON WASHINGTON COUNTY.

Grass Valley could be used to hold, as a reservoir, the surplus water from the Grass Valley Mountains in the spring, a large quantity of which now runs down the Santa Clara River, and no use whatever is made of it.

It is estimated that enough water could be stored to irrigate 2,000 acres at a cost of $10,000 by making a dam across Grass Valley.

There are good places at the mouth of Pinto Cañon for a reservoir to hold the surplus water from Pinto Mountains, and plenty of good land close by on which to use it.

Little Pine Valley, near Hebron, is also another good place for a reservoir, large quantities of surplus water running to waste in the spring from that section of country.

Dameron Valley, 12 miles north of St. George, could be used to store the surplus water of the Pine Valley branch of the Santa Clara River; this water would be very valuable to the city of St. George, which has the least amount of water for the number of inhabitants of any city or town in Utah.

Average depth of snow in mountains.

	Feet.
Pine Valley Mountains	4 to 10
South of Hebron Mountains	4 to 8
Grass Valley Mountains	4 to 10
Pinto Mountains	2 to 6
Hamblin Mountains	2 to 4
Kolob Mountains	3 to 6

Water necessary to irrigate crops.

	Inches.
Lucern and small grain	2
Fruit (peaches, grapes, etc.)	1
Corn	1

Clay and sandy soil require about the same amount of water. Sandy land requires more at each watering but does not need water as often as the clay land.

Crops need water in the lower part of our county every seven days, and the water should run for at least three hours; in the upper lands of the county once every fourteen days is sufficient.

The Rio Virgin is the most important river passing through our county. At the present time there is not more than 4,000 inches running below Price Canal. It is now our low-water season which usually lasts from the 15th of June until the 1st of September. Some portions of the year large bodies of water flow down caused through the melting of the snows and summer storms. The water of the Santa Clara at this time of year is all used by the Santa Clara Irrigating Company.

You will perceive that our seasons are very long in this section of the country, and in consequence where water is plentiful and land good we raise very heavy crops. We can cut four to five crops of lucern hay per year. Wheat and barley are harvested early in June, and a crop of corn raised on same land, thus you see we can raise two crops on same land per year where water is plentiful. Grapes, peaches, almonds, and such crops grow almost to perfection. All we want is water to put on the land, an abundance of which passes out of our country each spring unused.

Santa Clara irrigating district and St. George City lose at least on an average one-third of their crops each year for want of water; this loss could be saved if water was stored in Grass Valley, Little Cone Valley, and Dameron Valley as described.

NOTE.—The water measurement in this country is made on the "Weir Dam" system with 4-inch head.

On behalf of the county court, Washington County.

THOMAS JUDD,
MARTIN SLACK,
Special Commissioners.

After receipt and filing of these reports, the committee adjourned.

Washington County canals—Acres irrigated and cultivated, etc.

Names of canals.	When first built or used.	Streams from which water is drawn.	Irrigated and Cultivated.	Could be irrigated in new ditches and reservoirs.	Irrigating season.	Elevation above the sea.	Amount of water.	1 Cubic foot irrigates.	Remarks.
			Acres.	*Acres.*		*Feet.*	*Inches.*	*Acres.*	
Atkins and Sons	1876	Rio Virgin	160	.....	Apr. 1 to Oct. 15	2700	350	21.3	
Bloomington	1868	Rio Virgin and Santa Clara	125	.....	Mar. 1 to Oct. 15	2725	350	17	
Bellevue	1864	Ash Creek	120	100	....do	.....	.....	...	Plenty water in spring; dry towards midsummer.
Carter's Ranch	1864	Springs	140	.....	Apr. 15 to Sept. 15	.....	100	.....	At midsummer.
Cotton Farm	1876	Rio Virgin	50	.....	Mar. 15 to Oct. 15	.....	100	19	
Duncans	1862	.....do	94	.....	....do	.....	175	.....	
Earl's Springs	1868	Springs	45	.....	May 15 to Sept. 1	.....	60	25	
Grass Valley	1858	.....do	400	2,500	....do	.....	150	80	Considerable meadow.
Grafton	1862	Rio Virgin	117	.....	Mar. 15 to Oct. 15	.....	200	.....	
Hebron	1862	Springs	200	2,000	May 15 to Sept. 15	.....	100	70	Crops, grain and meadow raised without water.
Harmony	1863	Ash Creek	160	.....	....do	.....	200	60	Sometimes fail.
Hamblin	1866	Springs	200	500	....do	.....	100	.....	Some hay and grain raised without water.
Jarvis	1870	Rio Virgin	130	.....	Mar. 15 to Oct. 15	.....	250	.....	
La Verkin	1889	.....do	750	.....	....do	.....	1500	19	Canal now being built.
Leeds	1862	Quail Creek	300	200	....do	.....	400	.....	Sometimes falls to about 100.
Middleton	1862	Springs	125	.....	....do	.....	200	.....	
Mountain Dell	1863	North Creek	100	.....	....do	.....	150	.....	Sometimes dries up.
Price	1858	Rio Virgin	420	300	....do	.....	600	.....	
Pinto	1854	Springs	225	1,000	May 15 to Sept. 1	.....	325	.....	
Rockville	1862	Rio Virgin	270	200	Mar. 15 to Oct. 15	.....	540	.....	
St. George (town)	1862	Springs	300	2,000	....do	2850	155	.....	
Santa Clara, Irrigating District.	1854	Santa Clara	2,103	5,000	....do	.....	.....	.....	Plenty in spring; fails by midsummer. This includes all in the Santa Clara River, from Pine Valley to St. George field.
Springdale	1862	Rio Virgin	210	.....	....do	.....	375	.....	
Shomsburg	1862	..... do	110	.....	....do	.....	200	.....	
Tquerville	1858	Springs and Ash Creek and La Verkin.	383	.....	... do	.....	775	.....	Water sometimes scarce in dry seasons.
Virgin City	1859	Rio Virgin	165	.....	....do	.....	250	.....	
Virgin Field	1862	.....do	300	.....	....do	.....	600	.....	Dam been out of river for three years.
Washington (town)	1857	Springs	375	.....	....do	.....	250	.....	
Washington (field)	1858	Rio Virgin	800	5,000	....do	.....	1600	.....	
Westover	1876	.....do	15	.....	....do	.....	50	.....	

EXPLANATION OF PROFESSOR MARCUS E. JONES, DESERT UNIVERSITY.*

In the diagrams of the rain-fall of Salt Lake City, and of the oscillations of Great Salt Lake, already presented, the curves are made by letting a square (composed of four squares of the profile paper) represent a year between its vertical sides, and between its horizontal sides representing an inch of rain-fall and a foot of oscillation in the lake. The fine lines represent tenths of an inch of rain-fall and tenths of a foot of lake oscillation, respectively. The rain-fall of each year is drawn to the right side of the square representing that year. The unbroken lines represent known curves, while the dotted lines are hypothetical. The dotted rain-fall lines are merely tentative and may need revision, but there is not sufficient time for me to do this now. It issufficient to say that they are more liable to be too high than too low. As my object is to arrive at the normal rain-fall of Salt Lake City, and so of the whole arid region (for the relation of our rain-fall to the rest of the arid region is pretty well known), the conclusions drawn from these diagrams are sure not to be too low, and therefore the irrigable land in the arid regions that can be supplied with water by our normal rain-fall is equally sure not to be underestimated and is doubtless somewhat less than I have given it below.

The lines thus drawn from one square to another gives a graphic curve which shows to the eye irregularities that would not easily be perceived otherwise.

A comparison of the rain-fall curve of Salt Lake City with that of the whole country will show a general conformity, but with local minor variations. The most noticeable feature is that our wet and dry seasons come on the next year after they occur on the Atlantic coast. From the fact that climatic changes are continental it is possible to determine from the rain-fall curve of the whole country what the rain-fall of Salt Lake City has averaged as far back as 1800, by finding the relation of our rain-fall curve with that of the whole country from 1855 to the present.

The diagram of the Salt Lake City rain-fall is based on the records of the Signal Service since 1875, and on those of the post surgeon at Fort Douglas (3 miles east of this city) for the five preceding years, and on the records kept by W. W. and H. E. Phelps from 1855 to 1869. The Phelps records were carefully kept, but there appear many clerical errors in them, as published by the Smithsonian Institute and the Signal Service. Whether these errors were made by the observers in copying them, I do not know. I have therefore discarded the Smithsonian records and taken them as they were made out here, with here and there the correction of typographical errors. These records are uniformly too low by an inch, as shown by the oscillations of the lake, but this is chargeable to the poor quality of the instruments used in those early years. The rain-fall of Fort Douglas since 1877 (kept very carefully) is nearly 2 inches above that of Salt Lake City per annum, but previous to that time they were not carefully kept, and so to avoid understating our rain-fall, I have put the Fort Douglas records into the diagram at their full value.

In getting at our average rain-fall since 1800, we find that the average height of Great Salt Lake since 1884 has been about 7 feet above the Garfield zero. The annual rain-fall since that time that has had to do with the oscillation of the lake † has been about 15.4 inches, but the average height of the lake since 1840 has been over 1 foot below that of 1884 to the present, therefore the average rainfall of this place since 1840 is not above 14.5 inches. By referring to the diagram of the rain-fall of this country, prepared by Charles Schott of the Smithsonian Institute (a copy‡ of which is presented) it will be seen that the normal rain-fall of Salt Lake City for the last fifty years has been in excess of the normal for the century by an inch or more, since the rain-fall for the whole country for the last fifty years has exceeded considerably the average for the century, therefore it is quite probable that the average rain-fall of Salt Lake City since 1800 has been but little above (if not below) 13 inches per annum.

On this basis there are but 300,000 acres that can be cultivated in Utah to-day without additional reservoirs, estimating the duty of water at 1 cubic foot for 80 acres, and if the whole water supply that falls in the winter were saved we could cultivate 600,000 acres, but it will be impossible to save more than one-half of our winter rain-fall. Utah has a greater water supply, and, therefore, irrigable area than either Idaho, Nevada, Arizona, or most of New Mexico. With an annual rain-fall of 17 inches in the last ten years Utah has only 500,000 acres under cultivation, and this, too, with all of the unreservoired water supply fully used, with the exception of the waters of the Grand and Green Rivers, which can not at present be utilized from lack of capital.

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*Referred to in Prof. Jones's testimony (pages 172-175) and since forwarded to the committee by him.

† The very abnormal rain-fall of November and December, 1889, will be felt in 1890 and so does not belong in 1889.

‡ Added to his diagram (which stops at 1800) the rain-fall of Philadelphia up to 1887 and that of Salt Lake City up to 1890, to make it complete.

Salt Lake City has over twice the rain-fall of the valleys of Utah, Idaho, Nevada, Arizona, and New Mexico west of the Sandia Mountains, and the western half of Wyoming and Colorado. There are but three mountain ranges in this whole region whose snow-fall even slightly exceeds 40 inches of water in fall and winter, and the majority of the ranges have not over half of this snow-fall. On the loftiest of these ranges the snow belt never exceeds 20 miles wide, while in most of them it is very narrow. Viewed from the stand-point of the actual rain-fall of the arid regions, it becomes evident at once that it is impossible to irrigate even 10 per cent. of the 1,000,000 square miles that it is said may be reclaimed by irrigation. It is not probable that more than 10,000,000 acres can be reclaimed by any of the present methods of irrigation that are practicable on a large scale (subsoil irrigation, as at present conducted, is not practicable for general farming because of its great cost) in the arid regions, while the Salt Lake City rain-fall averages 17 inches per annum; while the sub-arid regions, embracing eastern Wyoming, Dakota, western Nebraska, eastern Colorado, western Kansas, eastern New Mexico, northwestern Texas, and parts of California will not bring the whole area up to 64,000,000 acres, *i. e.*, 10 per cent. of 1,000,000 square miles. But the fact that our irrigable area is so small makes it all the more imperative that the people of these regions should receive the aid they so greatly need.

To look at the irrigation question from the stand-point of the actual rain-fall is, in my judgment, the proper way, and this will at once show up the chimerical schemes of people who assume, without reason, that all they need is irrigation ditches, costly reservoirs, and tunnels run far into the mountains, and at once the fountains of waters will be opened and fill them. We can not get more water out of the mountains than falls upon them, nor can we save much more than half of what falls upon them.

The greatest needs of the arid regions to-day are elaborate experiments on the best methods of economy in the use of water (this in my judgment far overtops all others); erection of dams to utilize the larger rivers (like the Snake, Green, Grand, Rio Grande, Colorado, etc.), the building of reservoirs, uniform laws on water rights, uniformity in the methods of measuring water and in gauging streams, and the establishment of many signal stations in the valleys, and many places also in the mountains for the measurement of snow in winter.

As to the future of the arid regions, an inspection of the diagrams will give some valuable suggestions. From these it is evident that there have been two periods since 1800, one of twenty-four years of deficiency, and one of thirty-seven years of excess. We are now fourteen years along in a period of deficiency, and it is quite probable that we may have a decade more of deficiency before we have a long-continued excess.

It also appears that from the crest of the greatest waves of climatic change to the bottom (1808 to 1825, 1835 to 1862, 1862 to 1881, and 1881 to ——*) there are usually three smaller crests between; there is an abnormality in 1830, and an apparent, but not real one, in 1867. The diagram of Great Salt Lake shows that within these second minor crests there is a third series of three years each of comparatively uniform movement either toward excess or deficiency; sometimes there are two sets of deficient or excessive years in a downward or an upward movement, with a break between, but generally a series of three deficient years is followed by a series of three years of excess.

From these facts it is perfectly evident that there are oscillations in our climate. It is also evident that they are not uniform like the movements of a pendulum, and these changes are due to causes which it is out of place to discuss here.

Looking at the future with the evidence of the past, it is probable that we have not yet reached the end of the period of deficiency. Great Salt Lake is still 3 feet above its old level, and it is more probable that it will return to it before beginning its next grand upward movement. Be this as it may, it is reasonable to suppose that within the next fifteen years we shall enter upon a long period of general excess in our water supply over the normal for the last one hundred years, but not an excess over that from 1850 to 1875.

From these diagrams it is equally evident that from 1839 to 1860, when the prairies of the great West were still unturned by the farmer's plow (or but slightly on the eastern side), the rain-fall of the whole country increased, while from 1860 to 1881, the period when the great prairies of Iowa, Missouri, Minnesota, Dakota, Nebraska, Kansas, Arkansas, Texas, etc., were transformed into fields of waving grain, the rain-fall rapidly decreased, and even to the present has been below the normal.

The deserted ranches of the plains to-day also tell a sad story of the weakness of man's power to produce climatic changes, and it is hardly worth our while to plant ourselves in the desert, turn over the sod (if there is any), and expect the heavens to be opened in rain for our benefit and as a reward for tilling the soil.

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*Period of oscillation yet incomplete.

STATEMENT OF THE BEAR LAKE AND RIVER WATER-WORKS AND IRRIGATION COMPANY, MADE BY JOHN RANDOLPH BOTHWELL.

The project is not a new one. The vast body of arable land lying along both sides of Bear River just north of the Great Salt Lake has attracted attention from the time of the earliest settlement in this country. Here is the largest irrigable body of untilled land in all the mountain country. Bear River is the largest river in the thousand-mile stretch from Denver to Sacramento The diversion of this stream and the distribution of its waters upon the plain on both sides of its banks was looked forward to by Brigham Young even in the days when the Great Salt Lake Basin was sparsely peopled. A somewhat systematic effort in the same direction was undertaken about twenty years ago, and a survey was made with a view to estimating the cost of taking the water out of Bear River. Finding that the project called for a great expenditure, they appealed to Congress during the two following sessions with an appeal for a special act, allowing them to buy all the Government land under the proposed canal at the Government price of $2.50 per acre. One House of Congress passed the bill but it failed to be concurred in by the other, and the enterprise was abandoned.

Two or three years ago a new impetus was given to Utah by the extension westward of the great railways leading out from Chicago crossing the Missouri River, thence across Kansas and Nebraska into the mountain country. The movement was then organized which has resulted in placing the Bear River work under actual construction. A number of irrigation engineers from Colorado and California were called in consultation and the plan of work was laid out. Engineering crews were put in the field; the preparatory work was pushed ahead, and the first contract for construction was let on the 20th of July last. The water service, it is claimed, will be ready for operation for the season of 1890.

Although the works projected call for the expenditure of a large sum of money they are extremely simple in design, and involve no question of structural strength. The site for the headworks is simply ideal in its natural provisions for solidity of construction and for the care of surplus water.

In this company's plans it is claimed that not the headworks alone are in solid rock, but also the entire canal, so long as the great body of water is carried in undiaided volume. The earth cuts begin below the point where the water is divided.

The governing consideration has been to secure safety and permanency and the minimum of expense for operation and repairs. Wood structure has been almost altogether avoided. The water is led naturally, instead of being impounded. The river has a fall of 110 feet in the cañon, and the point of diversion is just above the fall. During high water no dam is required, and even in low water the surface must be raised only 3 feet in order to fill the canal to a depth of 10 feet.

The diverting dam is a movable structure, about 5 feet high, which can be taken out by two men in half a day. The canal at its initial point in mid-stream will be 7 feet under the surface of the river at low water. A subterranean channel is blasted out into the river with a flaring mouth opening out up-stream. As the channel reaches the rocky side of the cañon along shore, its bottom is 7 feet below the river level. The removable dam gives the extra 3 feet, making the water in the canal 10 feet deep. The headworks are to consist of eight gates, each 5 feet wide, the whole inclosed in masonry abutments, and protected by wing walls. The canal will then be carried down the cañon through the solid rock with a cross-section of 24 by 10 feet, and a grade of 4 feet to the mile—the estimated capacity being 2,000 cubic feet per second. At a distance of 6,800 feet from the headworks an iron bridge is to be thrown across the river and one-half of the volume of water is carried across to the westerly side. Both canals will then continue along the river banks for about 5 miles. The west branch is then to run across the plain on a grade of 1 foot per mile to the foot-hills on the west side, and to be flumed across the Malad River.

On reaching the foot-hills the canal turns south to Point Lookout. Here power will be developed by dropping 600 cubic feet per second 30 feet, amounting to 2,030 theoretical horse-power. Five hundred cubic feet are to be carried on around Point Lookout, in a southerly direction to Connor's Springs and Blue Creek. Main laterals will run from the west branch to water the country between the Bear and Malad Rivers and to supply Bear River City. A second lateral will be carried east of Little Mountain toward Corinne, and across the Central Pacific track to the Lakeside Ranch property. The east branch will run along the base of the Wasatch Mountains, gradually diminishing in width until it arrives at Hot Springs with a volume of 600 cubic feet per second. Of this amount 350 feet (cubic) will be dropped to the level of the plain, developing 1,388 theoretical horse-power, and from thence it is to be conducted to Plain City. The remainder, 250 cubic feet, is carried on to Ogden City and south, under the Union Pacific and Denver and Rio Grande Railway tracks, to the vicinity of Kaysville.

Reference to the map shows the district to be irrigated by this system to have a north and *south length of about 70 miles*, and a varying width east and west of from

15 miles down. It extends from township 4, north of the base line at Salt Lake, to township 13 north, or from a point about half way between the cities of Ogden and Salt Lake City to a point 50 miles north of Ogden. The Wasatch Range marks its eastern line, while the Promontory Range and the lake bound it on the west.

In an official report to the Department of the Interior at Washington, J. W. Powell, chief of the U. S. Geographical and Geological Survey, gives the following measurements of the irrigable lands which may be served:

	Square miles.	Acres.
Bear River Delta, Malad Valley and Connor's Spring Valley	218	139,520
Weber Delta Plain	219	140,160
Total	437	279,680

These lands were once a portion of the bottom of the Great Lake, whose lines are now distinctly marked on the surrounding mountain-sides hundreds of feet above the present level of the plain. For many years portions of the land near springs and creeks have been irrigated, and hundreds of small orchards and farms demonstrate the capability of the soil when supplied with water.

On the west side of Bear River the proposed canal does not intercept any streams except the Malad, which runs between steep banks far below the level of the plain and can not be diverted. On the east side of Bear River the canal intercepts several rivers and creeks which flow out from the Wasatch Mountains. The larger of these streams are the Weber and Ogden Rivers and Box Elder and Willard Creeks. These streams were appropriated by early settlers, whose lands were located on the lower plains where water could be distributed at the least cost. With the growth of the country cities were located near the mountains upon higher and choicer land. For several years past the demand for water for the growing villages has far exceeded the supply remaining to them after providing for prior appropriators. The only possible increase of supply must come from the Bear River.

NEVADA DIVISION.

CARSON CITY, NEV., *August* 22, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

STATEMENT OF MR. T. D. EDWARDS, SECRETARY OF THE NEVADA STATE BOARD OF RECLAMATION AND INTERNAL IMPROVEMENT.

Mr. Chairman and gentlemen: In behalf of the Navada State Board of Reclamation and Internal Improvement, which I represent, I beg leave to present the following facts for your consideration.

The CHAIRMAN. As I understand, that is a report gotten up by the State Board of Reclamation and Internal Improvement.

Mr. EDWARDS. Yes.

The report is as follows:

To the honorable Senate Committee on Irrigation:

The Nevada State Board of Reclamation and Internal Improvement beg leave to submit the following statement:

PHYSICAL CONDITION AND ADAPTABILITY.

Nevada lies between the thirty-fifth and forty-second degrees of north latitude, its boundaries commencing at the northwest corner of Utah Territory and the southern line of Idaho, at the intersection of the thirty seventh degree of longitude west from Washington (and 114° 03′ 57″ west from Greenwich) and in latitude 42 degrees north, and running thence west along the southern line of Idaho and Oregon to longitude 43 degrees west from Washington; thence south along the eastern line of California to latitude 39 degrees north, which falls in the southeastern part of Lake Tahoe; thence southeasterly along the California line to the intersection of the Colorado River, in latitude 35 degrees north and opposite Fort Mohave; thence north and easterly up the center of the Colorado River to its intersection with the thirty-seventh degree of longitude west from Washington, which is the eastern line of Utah Territory; thence north along the said western line

of Utah Territory to the place of beginning, containing within said boundaries 112,090 square miles or 71,737,600 acres.

Of this area there are surveyed, according to the report of the Commissioner of the General Land Office for 1887, 32,793,702 acres, and unsurveyed 38,943,898 acres. This area is approximately classified as follows by the State surveyor-general in his report for 1887–'88:

	Acres.
Water area	1,081,600
Forestry	2,000,000
Grazing	30,000,000
Agricultural lands	20,000,000
Mineral lands	15,000,000
Saline, borax, niter and sulphur deposits, alkali flats and deserts	3,656,000
Total	71,737,600

The agricultural class may be subdivided as follows: Irrigable lands about 12,000,000 acres, non-irrigable lands about 8,000,000 acres. By non-irrigable lands are meant lands that are agricultural in character, but upon which water can not be brought by reason of their elevation, but which, at the same time, can not be denominated grazing lands as they would be productive if irrigated.

Of the irrigable lands not more that 120 square miles are tilled in the State, and not more than one-third can now be irrigated on account of water running to waste by reason of imperfect utilization of the natural streams and springs and the failure to provide artesian and other artificial sources of supply. By the proper and scientific construction of reservoirs, dams, ditches, canals, artesian wells, and tunnels we are of the opinion that all, or nearly all, of the 12,000,000 acres of irrigable agricultural land in the State might be successfully irrigated.

TOPOGRAPHY.

The topography of Nevada is an elevated plateau, situated in the northwestern portion of the great basin. It has an altitude of 800 feet at the southeastern boundary, on the Colorado River, and nearly 7,000 feet at the northern boundary above sea-level, averaging about 4,000 feet.

It is traversed in a northerly and southerly direction by high parallel ranges, of mountains. These are separated by valleys from 5 to 25 miles in width and some of them are 50 miles in length, and one is 350 miles in length. Sage-brush covers nearly the entire surface of the State. It has been ascertained, by actual experiment, that wherever sage-brush grows the land will produce bountiful crops of vegetables, grains, and grasses, when irrigated.

LAKES THAT MAY BE UTILIZED.

Several important lakes are situated within the State, the most noted of which is Lake Tahoe (about one-third of which is in Nevada), it being the source of the Truckee River. It is 28 miles in length, 12 miles in width, and over 1,700 feet in depth.

Pyramid, Carson, and Walker Lakes are important bodies of water, receiving the waters discharged by the rivers of their respective names *and having* no outlets. All of these lakes can be readily utilized for

the purpose of irrigation. The most important lakes in Nevada are as follows:

Name.	County.	Area.
		Sq. miles.
Pyramid	Washoe	462
Carson (lower sink)	Churchill	440
Walker	Esmeralda	330
Humboldt	Humboldt	192
Carson (upper sink)	Churchill	160
Winnemucca	Washoe	144
Tahoe (portion in Nevada)	Washoe, Ormsby, and Douglas.	78
Ruby	Elko	37
Franklin	do	32
Washoe	Washoe	18
Snow Water	Elko	12
Massacre	Washoe	4
New Year	do	3
Carico	Lander	1
Marlette	Washoe	½
Forty-nine	do	½
Pahranagat	Lincoln	½

The Commissioner of the General Land Office, in his report for 1880, states the number of rivers and smaller streams in Nevada to be thirty-five and the number of lakes and ponds to be nine hundred and twenty-five.

RIVERS.

The principal rivers of the State are the Humboldt, Carson, Truckee, and Walker. The Humboldt River rises in the northeastern part of the State and flows southwesterly, emptying its waters into Humboldt Lake.

The other three rise in the Sierra Nevada Mountains (their sources being in the State of California) and flow eastward into the Carson, Pyramid, and Walker lakes respectively, all of which have no outlets. The Owyhee and Bruneau rivers, in the northern portion of Elko County, discharge their waters into the Snake, and the latter into the Columbia River, thence to the Pacific Ocean.

The Virgin and Muddy, in the southeastern portion of Lincoln County, empty their waters into the Colorado River, and thence to the Gulf of California.

Rich, fertile valleys, and numerous natural meadows extend along the various streams.

Following is a statement of the most important streams in the State:

	Miles.
Humboldt	350
Carson (length in Nevada)	190
Armagoza	150
Colorado (length on boundary of Nevada)	150
Reese	140
Little Humboldt	110
Walker (length in Nevada)	110
Truckee	97
Quinn (length in Nevada)	80
Owyhee (length in Nevada)	80
Virgin (length in Nevada)	80
Salmon (length in Nevada)	55
Bruneau	45
Mary's	42
King's	42
Muddy	40

If the waters of these rivers were utilized for the purpose of irrigating the valleys through which they pass, by a correct construction of reservoirs, dams, ditches, and canals, millions of acres that are now useless would be made to produce large crops of hay, cereals, and fruits of all kinds, adapted to the temperate and semi-tropical zones.

VALLEYS.

The following described are some of the principal valleys in the State, all of which can be irrigated from the waters of the rivers and tributaries flowing through them, if the waters thereof were systematically stored and judiciously used. The soil of these valleys is very rich, mostly alluvial deposits and highly productive. All the grains, grasses, fruits, and vegetables of the temperate and semi-tropical zones grow to perfection and in abundance whenever the soil is properly irrigated.

DOUGLAS COUNTY.

In this county is situated Carson Valley, 25 miles in length and an average width of about 10 miles, all of which can be irrigated from the waters of the Carson River.

The county assessor, in his report, says:

In this county there are thousands of acres of land, which in its present state, are entirely worthless, but whenever water can be obtained the land is exceedingly productive. Probably 90 per cent. of the water of the Carson River now runs to waste. If it could be stored in reservoirs in the mountains and used in the dry season, large tracts of land might be reclaimed and converted into homes for settlers.

In this county nature has provided most advantageous sites for reservoirs.

CHURCHILL COUNTY.

In Churchill County there is a valley, at and around the Sink of the Carson, with an area of about 40,000 acres, which could be irrigated by the waters of the Carson River, as estimated by the county surveyor.

WASHOE COUNTY.

In Washoe County the Truckee Meadows and Washoe Valley are situated with an area of about 25 miles in length and from 5 to 10 miles in width, all of which could be irrigated by a proper use of the water of the Truckee River.

In the same county we have Eagle Lake Valley, estimated at about 500,000 acres, which also can be readily irrigated from the waters of Eagle Lake by an open cut.

Spanish Springs Valley, Lemmon Valley, and Warm Springs Valley, estimated at 125,000 acres, can be irrigated with the waters from the Truckee River by the use of dams and reservoirs.

HUMBOLDT COUNTY.

In this county at a place called Lovelock's there are at least 100,000 acres of very fertile valley land, all of which is susceptible of irrigation by storage and a judicious use of the waters of the Humboldt River.

Humboldt Valley is one of the largest valleys in the State. It is estimated at 350 miles in length with a width in places of 20 miles and *at other places it* is narrow with an average width of about 8 miles. It *extends through* the counties of Lander, Humboldt, Eureka, and Elko.

This entire valley could be irrigated by the waters of the Humboldt River by a scientific series of storage dams, canals, reservoirs, and ditches.

Little Humboldt Valley and other small valleys adjacent thereto, including Paradise Valley, which is an extensive valley, are estimated at 250 square miles, all irrigable land.

King's River Valley is estimated at 40 miles in length with an average width of 8 miles, and can be irrigated by the waters of King's River.

Kelly and Rebel Creek Valleys, situated in Humboldt County, can be irrigated from the creeks adjacent and from which they take their names.

Pleasant Valley and many other valleys in this county are wholly susceptible of irrigation, and by a correct system of irrigation in these valleys a large area of valuable farming land could be reclaimed and made largely productive.

Quinn River Valley is about 42 miles in length by 12 in width, all fertile land and irrigable by the waters of Quinn River. This is one of the richest and most important valleys in the State.

ELKO COUNTY.

In this county is the south fork of the Humboldt River, which passes through a fertile valley, which is estimated at 150 square miles, of rich farming land, all of which could be irrigated by the waters of said stream.

Clover Valley, estimated at 50 square miles, is susceptible of being irrigated from the waters of adjacent streams and springs.

Mary's River Valley, Black's Fork, Susie Creek, and Maggie Creek Valleys, estimated at 100 square miles, can be irrigated from the creeks and streams passing over and through them. The soil of these valleys is very rich.

Independence Valley is estimated at 100 square miles, and is all susceptible of irrigation.

Bruneau and Owyhee Valleys, on the rivers of the same names, are large valleys and susceptible of irrigation by the use of the waters of said rivers. Also, Pleasant Valley, 30 miles in length by 6 in width, Lamoille Valley and Star Valley, the dimensions of which can not now be given. All very rich.

EUREKA COUNTY.

Pine and Garden Valleys are estimated at 50 miles in length and 8 in width, all irrigable land.

Diamond Valley has an area of 500 square miles, all rich land, that could be irrigated by an artesian system.

Grubb's Valley, a part of Monitor and Antelope Valleys, contains about 500 square miles, and can be irrigated by the artesian system.

WHITE PINE COUNTY.

In this county we find Newark Valley, which is estimated at 200 square miles. It could be irrigated by the artesian system. There are also many springs and streams in this county that could readily be utilized for irrigating purposes.

Steptoe Valley is estimated to have an area of 500 square miles of rich, arable land that can be thoroughly irrigated by the use of the waters

of the creeks and streams passing over and through it, and by springs in said valley and the surrounding hills.

Spring Valley contains a large area of rich land, and can be irrigated from adjacent springs and streams, if these waters were stored and judiciously used; area estimated at 250 square miles.

LINCOLN COUNTY.

Lake Valley and a part of Snake Valley, comprising a large body of rich land, are susceptible of irrigation by the storage of and the proper use of waters of streams on the land and of those adjacent thereto. This body of land is estimated at 50 square miles.

Eagle Valley is a large valley of importance, the area of which can not now be estimated.

Pahranagat Valley has an area of 150 square miles, very rich soil which will produce semi-tropical fruits and vegetables, and, by a system of storage, could be irrigated by streams upon and near it.

Muddy and Virgin River Valleys have an area of 150 square miles, and can be all thoroughly irrigated by the storage and use of the waters of the Virgin and Muddy Rivers. The climate here is semi-tropical.

Las Vegas Valley has an area of 50 square miles, and is irrigable.

Meadow Valley and Cave Valley, as estimated, have an area of 100 square miles, all fertile lands, and susceptible of irrigation.

NYE COUNTY.

Pahrimp Valley, which lies partly in Lincoln County, has an are of 65 by 35 miles. There is no richer or more fertile land on the globe. It rivals the richest portion of the Mississippi Valley. Seventeen hundred and fifty square miles of this valley are in Nevada. This valley could be irrigated successfully by an intelligent use of the springs thereof and the artesian system.

Duck Valley, in this county, has an area of 400 square miles, all of which is irrigable.

LYON COUNTY.

In this county there is Smith Valley, which has an area of about 50 square miles. It is rich farming land, about one-third of which is under an imperfect state of cultivation. The entire valley could be thoroughly irrigated by husbanding the waters of the West Walker, which now run to waste in the early part of the season in consequence of there being no system of storage.

In the same county we find Antelope Valley, the approximate area of which is 120 square miles, about one-fourth of which is under cultivation. It is watered by the West Walker. This valley is in the same condition as the previous mentioned valley. There is sufficient water in the West Walker thoroughly to irrigate both valleys if stored and economically used, but having no water storage in the early season the waters from the melting snows and early rains is wasted and lost.

ESMERALDA COUNTY.

In this county we find Mason Valley, with an approximate area of 250 square miles, watered by the East and West Walker. About one-fifth is imperfectly cultivated. If the waters of said rivers were properly stored by dams and reservoirs there would be sufficient to thoroughly *irrigate the entire* valley.

If the waters which pass over, through, and adjacent to all or nearly all of the foregoing valleys as the snows melt in the early season could be systematically and scientifically stored in reservoirs and dams, advantageous sites for which are abundant, and economically used during the irrigating season, there would be sufficient thoroughly to irrigate these valleys from the 1st of May to the 1st of October, which in this country constitutes the irrigating season. As the practice now is, fully nine-tenths of the water running down our streams goes to waste.

Many of these valleys are surrounded by or in the vicinity of high mountains, upon which, during the winter, deep snows fall, and on the summits of some the snow is perpetual.

In the early spring these snows melt and produce large quantities of water, which pass down the mountain sides and smaller streams, and sometimes create floods, passing on and finally sinking in the deserts, being lost for irrigating purposes. If this vast amount of water could be stored as the snow melts and runs down the mountains, we claim that there would be ample to irrigate the valleys during the irrigating season. Nature has provided numerous and advantageous sites for the construction of such reservoirs in all parts of our State.

SPRINGS.

As shown by the bulletin of the U. S. Geological Survey, No. 32, the State of Nevada is even better off in regard to springs than as to streams of running water. They form an important auxiliary, and might be caused to aid materially the agriculturist in the increase of his tillable area of land.

Nevada occupies a prominent place as a mineral-spring State; both hot and cold springs are found in every county. The warm and hot springs are found mainly in connection with geological fault-lines or fractures of the strata. Can we not, from these facts, reasonably conclude that the sinking of artesian wells would not only be advisable, but that the probabilities of obtaining large streams of water therefrom are great?

The following is a list of mineral springs, as given by the U. S. Geological report:

ALKALI SPRINGS.

Seven miles north of Montezuma, Esmeralda County.
Ten miles northwest of Lone Mountain, Esmeralda County.
Allen's Springs, south of Carson Lake, Churchill County.
Alum Spring, 5 miles northeast of Steamboat Springs, Washoe County.
Bitter Springs, 15 miles southwest of St. Thomas, Lincoln County.
Butte Spring, north end of Hot Springs, Butte, Humboldt County; 182° Fah.
Double Spring, north of Walker Lake, Esmeralda County; temperature, warm.
Double Hot Springs, southwest flank of Black Rock Range, Humboldt County; 165° to 191° Fah.
Elko Hot Springs, Elko, Elko County; resort.
Franktown Hot Springs, Franktown, Washoe County.
Golconda Hot Springs, Galconda, Humboldt County, six spring; 150° Fahr.; character of water, chalybeate and sulphur; resort.
Goodrich Springs, 12 miles from Schellbourne, White Pine County; flow in gallons per hour, 28,000; 160° to 185° Fah.; unimproved.
Granite Creek Hot Springs, near Alkali Lake, north of Granite Creek Desert, Humboldt County.
Gypsum Springs, 20 miles northeast of Las Vegas, Lincoln County.
On north side of Thousand Creek Valley, southwest of Stein Mountains, Humboldt County; 130° Fah.; unimproved.
In Soldier Meadows, 15 miles south of Camp McGarry, Humboldt County.
At south end of Stein Mountains, Humboldt County; 178° Fah.

Ten or 12 miles north of Mason's Crossing of Quinn River, Humboldt County; number of springs, 2; 118° to 134° Fah.; character of water, calcic.
On east side of Independence Valley, Elko County.
At northeast end of Ruby Lake, Elko County.
East of Division Peak and south of Pah Ute, Humboldt County.
On northeast side of Pine Valley, north of Mineral Hill, Eureka County.
South of Alkali Lake, east side of Crescent Valley, Eureka County.
On northeast side of Pah Ute Mountains, Churchill County.
In Antelope Valley, near Eagle Lake, Elko County.
Northwest of sink of Quinn River, Humboldt County; number of springs, 2.
Near Egan Cañon, 15 miles northwest of Schellbourne, White Pine County; used for quartz mill and for bathing.
At northwest end of Pyramid Lake, Washoe County.
At north end of Pyramid Lake, Washoe County.
On Carson River, 6 miles northeast of Genoa, Douglas County.
At south end of Smoke Creek Desert, Washoe County.
At north end of Toquima Range, 18 miles southeast of Austin, Lander County.
Near junction of Beef and Virgin Creeks, Humboldt County; 108° Fah.
On Little Humboldt, north of Hot Spring Creek, Humboldt County; 130° Fah.
In Kobeh Valley, near Grubbs' Wells, Eureka County.
On west side of Smith Creek Valley, Churchill County.
On west side of Gabbs' Valley, Esmeralda County.
One mile east of Carson City, Ormsby County (at State's prison); 111° Fah.; improved.
Ten miles north of Wellington, Lyon County (Hinds'); flow of water per hour, 91,000 gallons; 40° to 140° Fah.; resort.
East of Hot Springs Station, Churchill County; number of springs, 6; 158° to 187° Fah.
East of Winnemucca, Humboldt County; 189° Fah.
At head of north branch of Little Humboldt, Humboldt County.
At head of south branch of Little Humboldt, Humboldt County.
On southwest side of Black Rock Range, Humboldt County; number of springs, 3.
At south end of Black Rock Range, Humboldt County.
Near south end of Pine Forest Range, 7 miles from Mason's Crossing of Quinn River, Humboldt County; 155° Fah.
In Emigrant Cañon, northeast of Tulasco, Elko County.
At south end of Thousand Springs Valley, Elko County.
At Cephas Kyles, 7 miles south of Sue Springs, Churchill County; 124° Fah.
At base of Shoshone Range, Reese River Valley, Lander County; 85° to 117° Fah.
In Steptoe Valley, southwest of Ruby Valley, White Pine County.
Near Silver Peake, Esmeralda County, eleven springs; 69° to 117.8° Fah.; saline, etc.
Fourteen miles south of Toyiabe City, Nye County, one spring; flow in gallons, per hour, 35,000; temperature, boiling.
In Diamond Valley, 30 miles north of Eureka, Eureka County.
In Hot Spring Range, Nye County; two springs; temperature, boiling.
In Salt Valley, east side of Carson Sink Mountains, Churchill County.
Hot Sulphur Springs, Carlin, Elko County.
Kyle's Hot Springs, 12 or 15 miles east of Star Peak, Humboldt County; resort.
Las Vegas Springs, Las Vegas, Lincoln County, 73° Fah.; calcic.
Leach's Hot Springs, Pleasant Valley, 25 miles south of Winnemucca, Humboldt County; 118° Fah.
Mesquit Springs, 10 miles east of Las Vegas, Lincoln County.
Miller's Hot Springs, 10 miles north of Franklin, Ruby Valley, Elko County; 170° Fah.
Mineral Hill Hot White Sulphur Springs (Bruffy's Hot Springs), 4 miles north of Mineral Hill, Eureka County; five springs; flow in gallons per minute, 150; temperature, boiling; sulphureted; resort.

MINERAL SPRINGS.

Opposite Stonehouse Station, Humboldt County.
West side of Smoke Creek Desert, Washoe County.
Muddy Springs, northwest of West Point, Lincoln County; twenty springs; temperature, hot.
Mud Springs, Desert Wells, Nye County.
Nelson Springs, 20 miles south of Golconda, Humboldt County; temperature, hot.
Red Bluff Springs, 10 miles east of St. Thomas, Lincoln County; alkaline, saline.
Rotten Egg Springs, west side of Mud Lake, Washoe County.
Salt Well, 1 mile north of Stone's Ferry, Lincoln County; 89.5° Fah.; saline.
Shellbourne Hot Springs, Shellbourne, White Pine County; two springs; used for *irrigation.*

Shaw's Hot Springs (formerly Swift's), 2 miles northeast of Carson City, Ormsby County; one spring, flow in gallons per hour, 4,000; 120° Fah.; soda, borax, iron, magnesia, arsenic; resort.
Hot water of Ophir Mine, Comstock Lode, Virginia City, Storey County.
Smoky Valley Geysers, Nye County; flow, 4,200 gallons per hour; boiling.
Soda Lakes, 3 or 4 miles east of Ragtown, Churchill County; alkaline, saline.

SODA SPRINGS.

East of South Carson Lake, Churchill County; 178° Fah.
South of Silver Peak, Esmeralda County.
Near Butterfield's Warm Springs, west of Railroad Valley, Nye County; saline, etc.
Steamboat Springs, Steamboat, Washoe County; 204° Fah.; resort.
Sue (or Gilbert's) Hot Springs, north end of Osobb or Salt Valley, Humboldt County; 160° to 185° Fah.

SULPHUR SPRINGS.

In Esmeralda County, 12 miles southeast of Wellington.
In Sodaville, Soda Springs Valley, north of Columbus, Esmeralda County; improved and used as a resort.
At south end of Diamond Valley, Eureka County.
Seven miles east of Montezuma, Esmeralda County.
Eight or nine miles northeast of Toyabe City, Nye County.
Twenty miles south of Freibergh, Lincoln County.
In Pahrimp Valley, Lincoln County.
At Sand Spring Flat, 15 miles south of Stillwater, Churchill County; hot.

THERMAL SPRINGS.

On east side of Little Cedar Mountains, Elko County.
At east base of Keene Mountains, San Antonio, Nye County; three springs; alkaline.
Five miles east of Patterson, Lincoln County.
Virgin River, Lincoln County; strongly saline.
Volcanic Springs, Whirlwind Valley, Eureka County, 10 miles south of Beowawe.
Wabuska Springs, Wabuska, Lyon County; 138° to 162° Fahr.
Walley's or Genoa Hot Springs, Genoa, Douglas County; six springs; flow 600 gallons per minute; hot; iron and sulphur; resort.
Ward's Hot Springs, foot of Granite Mountains, Humboldt County; boiling.

WARM SPRINGS.

North of Shoshone Mesa, west of Rock Creek, Lander County.
On White River, in Sierra Valley, 20 miles northwest of Butterfield, Nye County.
South of Sonoma Range, Humboldt County.
On west side of King's River Valley, Humboldt County; number of springs, two; 76° to 80° Fahr.
Eight miles southwest of Camp Halleck, Elko County.
At Hiko, Lincoln County; 90° Fahr.
In Pahrimp Valley, Lincoln County.
West of Robert's Mountain, Eureka County.
Northwest of Tecoma, Elko County.
South of Alkali Lake, Reese River Valley, Lander County.
On west side of Warm Spring Valley, Nye County.
At north end of Grass Valley, Lander County.
In Storey County, 10 or 12 miles south of Wadsworth; 73° Fahr.
At north end of Carrico Valley, Lander County.
At east side of Sonoma Mountains, Humboldt County.
In Fish Spring Valley, southeast of Danville, Nye County.
Six miles north of Hot Springs, Smith's Creek Valley, Churchill County.
In Ash Meadow, Nye County; 81.6° Fahr.
At north end of White Pine Valley, White Pine County.
West of Fish Creek Range, Lander County; 140° Fahr.
Warm Sulphur Springs, south end of Spring Valley, White Pine County.
Whelan's White Sulphur and Mineral Springs, Pine Valley, 12 miles north of Mineral Hill, Eureka County; three springs; flow per hour, 5,000 gallons; 108° to 112° Fahr.; local resort.

The above list includes only mineral springs, besides which we have many important springs. Some of these have very large flows, notably two at Bennett's Ranch, in Pahrimp Valley, which irrigates 2,500 acres, and three in Pahranagat Valley (Hiko, Logan, and Ash), each of which has a flow of *from 1,000 to* 2,000 inches.

RESERVOIRS AND ARTESIAN WELLS.

According to the assessors' reports to the surveyor-general for 1888, there were in our State only eighteen reservoirs, their total capacity being 591,576,000 gallons.

Natural depressions between the summits and ridges of the many mountains, and in the foot-hills at their base, form sites admirably adapted for immense and inexpensive reservoirs.

There were, in 1888, sixty-five wells sunk in our State, ranging in depth from 109 to 310 feet, twenty-five of which were 6 inches in diameter, averaging in flow about 20 gallons per minute.

The others have a diameter of 3 and 4 inches, and vary in flow from 11½ to 33 gallons per minute.

In a dispatch from Washington to the San Francisco Chronicle, January 3, 1889, referring to Major Powell's report, we find the following:

Early in November, H. M. Wilson, with parties under his immediate charge * * * was transferred to Nevada, near the headwaters of the Truckee, Carson, and Walker Rivers, and immediately began the work of an irrigation survey. Speaking of Lake Tahoe, he says: "This is a lake filled from a catchment basin of 500 square miles. This storage lake, constructed by nature, has only to be tapped and gateways constructed and it can be used at once, and the water which is gathered through the non-irrigating season, may, through the irrigating season, be discharged again into its natural channel, in addition to the waters which fall from the heavens during that season; the whole to be carried down to diverting dams in the valley below and turned into irrigating canals to be spread over the land in the total area available for irrigation to which the water of the Truckee may be carried.

"It is probable that an acre-foot of water, *i. e.* an acre of water 1 foot deep will abundantly irrigate an acre of land through one season, and it is possible to store in Lake Tahoe 500,000 acre-feet, which can be made to irrigate 500,000 acres of land. This can be done by providing for the discharge of 4 feet of water from the surface of the lake through each irrigating season, and providing for the conservation of the same amount annually contributed by the clouds. The survey has not yet proceeded far enough to determine where these lands can be selected.

"This case has been here cited simply as an illustration of the manner in which the natural lakes of the mountain regions of the arid land can be economically utilized as storage reservoirs. Such lakes exist in great numbers. Altogether there are several hundred, each of which must be carefully examined and carefully surveyed in order to determine the methods by which it can be used."

Wells and reservoirs.

[From surveyor-general's report, 1887-'88.]

Counties.	Artesian wells—1888.				Reservoirs—1888.	
	Number.	Depth.	Size of pipe.	Flowing capacity 24 hours.	Number.	Capacity.
		Feet.	*Inches.*	*Gallons.*		*Gallons.*
Churchill	2	1....300 1..2,100	4	2,000		
Douglas	2	1....225 1....310	3	43,200		
Elko					1	
Esmeralda	1				1	
Humboldt					2	876,000
Lander	25	150 to 200	6	*28,800		
Lincoln						
Lyon						
Nye					6	581,000,000
Ormsby	35	1....109 1....150 1....138	3	(48,960 15,000 15,000	6	2,500,000
Storey					1	7,000,000
Washoe						
White Pine					1	200,000

*Average.

CLIMATE.

Nevada possesses an equable climate. Extremes of heat and cold are seldom experienced.

The precipitation of melted snow and rain, as shown by the report of the Nevada State weather service, is as follows for the year 1888:

Station.	County.	Months.	Precipitation.
			Inches.
Wellington	Douglas	12	8.11
Hot Springs	Churchill	7	2.32
Burner's Ranch	Elko	8	18.53
Eureka	Eureka	9	7.15
Mill City	Humboldt	8	5.08
Battle Mountain	Lander	11	10.92
Piocho	Lincoln	12	18.27
Dayton	Lyon	8	4.86
Carson	Ormsby	12	7.12
Reno	Washoe	11	6.62
Lewer's Ranch	do	6	6.14
Ely	White Pine	10	9.64

Nearly all of the above stations are situated in valleys, where the precipitation is much less than on the surrounding mountains.

AGRICULTURE.

Possessing as rich a soil and as fine a climate as any region in the temperate zone, Nevada, with a systematic and scientific plan of irrigation, which could be brought about by an intelligent system of water storage and artesian wells, would be one of the most productive States in the Union. Her farmers are beginning to realize the fact that the agricultural resources of the State are comparatively undeveloped. The mineral composition of the soil renders it superior to the rich, black loam of the Western States, its elements being those that give enduring strength, by constantly receiving benefits from the decomposition and segregation of rocks, pregnant with mineral properties, which tend to fertilize it.

As shown by the reports of the assessors, there are planted 279,279 apple trees, 39,833 grape vines, 4,452 almond trees, all of which are flourishing and yield abundantly, showing that the climate is adapted to the production of both temperate and semi-tropical fruits.

Timothy, red clover, and natural grasses produce as much if not more to the acre than elsewhere, when the soil is properly irrigated. Alfalfa is produced in abundance whenever the land can be given sufficient water—two and sometimes three crops, and in southern Nevada, from four to six crops from the same land in one season, each yielding from 2 to 2½ tons per cut to the acre, and in some localities even more.

All fruits and berries adapted to the temperate zone grow to perfection, and being free from diseases and insect pests yield abundantly and command higher prices in the market than like products from other States.

In Lincoln and Nye Counties grapes and all the semi-tropical fruits, in addition to those of northern climes, can be grown as successfully as in California or Florida. In the Vegas, Pahrimp, Pahranagat, and Rio Virgin Valleys grapes are successfully cultivated. In the last-named valley, 30,000 grape-vines and 3,452 almond trees are owned and cultivated by Daniel Bonnelli, esq., who reports them to be as thriving as those in the most favored *sections in* France.

Cotton, tobacco, and citrus and semi-tropical fruits of all kinds and of the best quality flourish in these valleys.

A brief sketch of Pahranagat and Pahrimp Valleys may not be inappropriate in this connection.

PAHRANAGAT VALLEY.

This valley is situated in Lincoln County, and lies at an elevation estimated at from 6,000 to 7,000 feet above sea-level, but, for so great an altitude, the climate is warm and pleasant. This is accounted for by its being in a measure open to the valley of the Colorado and the warm region of the south. Very slight snow-storms are experienced in winter, and frosts are not severe. Springs and streams afford water for irrigating a large area, and with good soil and mild climate combine to generate such products of the farm, garden, and field as the people desire. The springs, of which there are three (Hiko, Logan, and Ash), are natural curiosities, because of the volume of the water they pour forth (from 1,000 to 2,000 inches each) and the peculiarity of their high temperature (from 65° to 75° Fahr.). In the neighborhood of each of these are farming settlements, and at Hiko and Logan small villages.

PAHRIMP VALLEY.

Situated south of the great Armargoza Desert, west of the Spring Range of mountains, in longitude 116 degrees west, latitude 36 degrees north, lying partly in Nevada and partly in California, is Pahrimp Valley, destined some day to be famous for its fertility, and is one of the most, if not the most, fertile of spots in the United States.

Pahrimp Valley is partly surrounded by mountains, varying from 6,000 to 12,000 feet high, and covered with a heavy growth of timber, principally yellow-pine, nut-pine and tamarack, which will afford, almost forever, a continual supply of lumber and fuel for all who need them. The scenery of these mountains is particularly magnificent, and standing upon one of the knolls or hills that skirt the edge of the valley, one can see stretched out before him a plain 65 miles long by 35 miles in width, and covered with a dense undergrowth of sage-brush and grease-wood. If you go down into the valley you will find beneath this gray exterior a soil that is excessively rich, and at intervals springs of flowing water. In this valley there is at least calculation 250,000 acres of as fertile land as there is on the globe. To prove this assertion we will describe a farm there known as Bennett's. On this place there are two springs of flowing water which irrigate 2,500 acres of land, and this land is no more fertile than several hundred thousand other acres in the valley just like it. The principal crops at Bennett's are alfalfa, grain, corn, fruits of all kinds, and grapes, in fact, everything belonging to the vegetable kingdom that has been tried there has flourished. Alfalfa is cut four times a year and then leaves good pasturage; corn yields as abundantly as on the famous Mississippi bottoms, and certainly better than in any of the Western States, while fruits do excellently, figs, almonds, walnuts, apples, nectarines, peaches, pears, apricots, etc., being raised in abundance.

Upon the summits of the surrounding hills, the snow-fall is quite heavy, ranging from 2 to 12 feet, and upon Charleston Peak is perpetual. A greater part of it melts early in the season and runs down the hillside to sink in the soil, re-appearing as the aforementioned springs.

In the valleys of the Virgin and Muddy Rivers cotton is successfully

ed. The report of the assessor of Lincoln County, for 1888, shows ; 49 acres are cultivated, with a yield of 19,600 pounds (or 400 nds per acre), of a quality equal to any grown in the United States. .s there is no home market in Lincoln County for this article, and ost no transportation facilities, it is not extensively raised; but the ve shows that with improved irrigation facilities (and with the con- uent enlargement of the resources of the country better transpor- on facilities will be obtained), a large area of land would be opened on which all the staple products of the semi-tropical zone could be ed in abundance.

Ve are largely indebted to the State surveyor-general's report for 7–'88, for many of the figures and facts above stated, and we be- e that many of our estimates are under rather than over the real s. The annexed tables will illustrate this:

Principal agricultural products of Nevada in the years 1887–'88.

ounties.	Land.				Wheat.			
	1887.		1888.		1887.		1888.	
	Inclosed.	Cultivated.	Inclosed.	Cultivated.	Acres.	Bushels.	Acres.	Bushels.
	Acres.	*Acres.*	*Acres.*	*Acres.*				
·hill			34,715	6,023			275	4,466
las	33,084	14,826	33,100	14,713	820	14,760	750	*14,760
			219,530	47,150			1,060	23,497
ralda			6,000	4,000			100	1,000
ka			36,348	12,405			250	6,250
boldt	195,600	8,400	141,500	26,234	5,500	85,000	10,030	200,890
er			55,643	2,500			300	9,000
ln	10,511	3,612	10,550	3,700	398	9,962	400	9,962
			34,000	8,000			600	12,000
by	4,676	1,813	5,039	1,871	196	3,800	180	3,600
y		1,050		700			20	600
oe	43,430	8,560	45,148	8,700	2,040	24,960	1,713	20,376
e Pine	20,000	12,900	25,000	5,500	100	4,000	100	4,000
	309,301	50,291	646,343	141,496	5,054	142,484	15,718	311,901

ounties.	Barley.				Oats.			
	1887.		1888.		1887.		1888.	
	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.
·hill			567	15,080			53	1,590
las	1,305	33,700	4,305	*33,700	1,960	49,000	*1,900	47,500
			2,810	78,150			2,270	91,470
ralda			10	400			20	150
ka			600	21,000			150	5,250
boldt	3,400	84,200	15,019	375,960	100	4,000	250	20,000
er			2,200	38,000			5	200
ln	1,040	26,012	1,200	30,000	209	7,315	250	8,950
			1,300	32,500			260	9,100
			1,780	52,917			150	6,250
by	415	7,885	469	8,711	116	4,060	7	*245
y			3	120				
oe	1,370	12,130	1,418	10,855	660	11,492	571	11,313
e Pine	1,000	30,000	1,000	40,000	400	20,000	150	6,000
	8,480	194,027	28,741	737,393	3,445	95,867	6,035	208,918

Principal agricultural products of Nevada in the years 1887–'88—Continued.

Counties.	Potatoes.				Hay.			
	1887.		1888.		1887.		1888.	
	Acres.	Bushels.	Acres.	Bushels.	Acres.	Tons.	Acres.	Tons.
Churchill			8	2,300			6,140	10,120
Douglas	120	7,500	80	*5,040	10,372	15,558	10,572	*15,858
Elko			305	25,065			40,650	44,370
Esmeralda			6	1,400			1,200	2,000
Eureka			300	45,000			11,000	15,500
Humboldt	50	5,000	107	12,490	20,000	25,000	50,652	200,168
Lander			215	20,600			6,000	5,400
Lincoln	91	5,460	93	5,580	3,342	6,684	3,400	6,800
Lyon			268	85,760			12,480	24,960
Nye			160	10,667			2,323	4,645
Ormsby	120	10,800	140	13,140	880	1,980	897	2,018
Storey			60	4,550			300	1,000
Washoe	397	43,620	359	49,676	18,460	41,120	18,523	43,077
White Pine	500	50,000	100	10,000	8,000	12,000	4,000	5,000
	1,278	122,380	2,201	301,183	61,054	73,342	168,137	380,914

Counties.	Butter.		Cheese.		Wool.	
	1887.	1888.	1887.	1888.	1887.	1888.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Churchill		7,900		1,500		148,000
Douglas	20,000	22,000			2,000	2,000
Elko		32,000		1,000		196,800
Esmeralda		1,000				
Eureka		40,000				97,987
Humboldt		24,000			400,000	666,600
Lander		15,000				126,900
Lincoln	9,800	10,000	6,000	6,000	46,800	46,800
Lyon		38,000				70,000
Nye						108,550
Ormsby	9,740	9,480				
Storey		1,800				700
Washoe	90,740	91,105	28,200	21,050	400,090	350,000
White Pine	10,000	15,000	2,000	1,000	150,000	210,000
	140,280	286,285	36,200	28,550	998,800	2,024,337

* Crop for that year unknown, and the previous year is taken as basis.

Smaller crops—total for the State.

Product.	1887.		1888.	
	Acres.	Bushels.	Acres.	Bushels.
Corn	446	13,760	610	16,626
Rye	167	1,727	207	1,939
Onions	68½	2,509	49½	2,768
Peas	68½	1,632	189	4,077
Beans	66	1,615	66	1,683
Cabbage	82½	*324	121	*364½
Hops			10	†2,000

* Tons. † Pounds.

Trees and vines in the State.

Trees.	1887.	1888.	Trees.	1887.	1888.
Apple	253,969	279,259	Walnut	1,721	2,014
Peach	8,090	11,628	Willow	5,803	5,841
Pear	10,471	14,002	White maple	5,631	7,723
Plum	9,720	12,009	Poplar	107,894	98,423
Cherry	7,332	8,059	Cottonwood	206,840	315,228
Nectarine	278	252	Elm	25,813	26,691
Quince	1,058	1,087	Box elder	14,616	12,795
Apricot	836	1,475			
Fig	245	278		368,318	468,715
Lemon		1			
Orange	2		Miscellaneous (including ornamental trees, shrubs, etc.)	80,562	43,064
Pomegranate		6			
Prune	3,025	4,032	Grapevines		
Mulberry	831	875	Strawberry, gooseberry, raspberry, and currant bushes.	37,588	39,975
Almond	3,371	3,452		365,665	625,401
	299,228	336,415		403,253	665,376

HOW SHALL THIS GREAT WORK BE DONE?

Many of the States and Territories in the arid region advance the following propositions:

(1) The General Government to undertake the reclamation of the arid lands and provide for their settlement and sale.

(2) That the desert-land law be so amended as to encourage individuals and companies to construct the necessary works for the reclamation of large bodies of said land.

(3) That Congress grant to each State of the arid belt, or to each Territory, upon its becoming a State, all the irrigable land within its borders, held by the General Government, such States to be charged with the supervision of their reclamation, and with their disposal to actual settlers.

Of these, we favor the last. If the General Government feels that it would not be warranted in donating outright the money necessary to accomplish the desired end, then let it act as liberally as it can without detriment to the equity of other States, whose humidity is sufficient for all their requirements, and transfer in fee-simple to the State of Nevada all the lands in that State the title to which is now in the General Government and not otherwise appropriated.

Were these lands put in legal condition to be sold to actual settlers, firms, corporations, and syndicates, the money derived from such sales could be placed in a fund to be known as the "State reclamation fund," the sale of said lands and the control of said reclamation fund to be managed by a State board. The money accruing to this fund could be used for the purpose of reclaiming such lands, and for the construction of storage reservoirs, canals, and tunnels; and thus induce the purchase, by the farmer, of lands upon which he would be guaranteed the necessary water for irrigation.

Thus all the irrigable lands in the State would be in demand by actual settlers, and money would flow in as fast as it could be utilized, and the fund would be found ample to do the work required.

Should the General Government be unwilling to make a donation of money, but will make this donation of land, the end would be accomplished, no doubt, as readily and thoroughly as by any other means.

AID TO NEVADA.

The State has but a small tax-roll compared with other States. This board was only organized May 9, 1889. The State has appropriated $100,000, *so that this board could* make a beginning. It is to the Gen-

eral Government that we most look for aid to carry on this great work. The title to most of the irrigable land in the State is in the Government, so that should the Government assist us it would at the same time benefit itself.

Again, while other States have had large Congressional appropriations for river, harbor, and other improvements, Nevada has received nothing. Would it not be even-handed justice if, in lieu of river and harbor appropriations, we should have an appropriation for the construction of reservoirs?

The fostering care of the General Government should be extended to all the States of the Union without distinction or discrimination. Nevada, as one of the integral parts of the Union, asks that this be done in its behalf now, at a time in its history when its needs are more pressing than at any period since its organization as a State. Its mines, which for many years were the envy of the world, have very materially fallen off in their production of gold and silver, and very many of the people engaged in that industry have departed to other fields. There now remains a population of probably 63,000. Of these the great majority are engaged in other pursuits than mining. The miner, having dug his treasures from the bowels of the mountains, had no further use for the country, and left behind him only the tiller of the soil, or, to speak more in the parlance of the great West, the rancher. This individual, with a persistence worthy of better success, has made productive every acre of arable land to be found along the water-courses of the State, or where, by small expenditure, land could be irrigated, he did so with much success, considering the capital invested and the opportunities presented. There being no more land available for farming in this way, if the area of producing land is to be increased, it must be done by a system of irrigation fostered by the General Government. Of what that system shall consist, or how it shall be established, perhaps others more versed in such problems than ourselves should determine; but it must be done, or the State, which has within its borders thousands of acres of productive land, must remain as it is, poor in wealth and sparse in population. Such being the condition of things, can the General Government refuse to render assistance, or will it allow one of its sovereign States to languish, when a very small moiety from its treasure-house would place it in a condition of permanent prosperity, and add to that State's capacity for increasing its wealth and supplying homes for a greater number of inhabitants? Surely the policy of this great Government is broad enough, is expansive enough in its conception of what is beneficial for the good of its whole people, not to allow the parsimony of the huckster to stand in the way of aiding and fostering one of its great commonwealths.

One of America's greatest statesmen said that the three most pressing needs of primitive man were food, raiment, and defense. Of the latter the people of Nevada stand not in need. But food and raiment are as much a part of their pressing needs to-day as they were to primitive man, and successfully to get them is as much a problem to the average sage-brusher as it was thousands of years ago, when the world was young.

The General Government can help solve this problem by aiding this struggling people in a manner different from the aid given to the people of other States. Nevada has no harbors within its confines to be seawalled or dredged, nor does it ask for expensive light-houses to light the commerce of the world to its custom-house doors, nor has it a river *requiring improvement* or the expenditure of money to make it navi-

gable, save, indeed, the Colorado, which in other years may be deemed a stream of sufficient importance upon which the Government may expend labor.

Nevada is particularly an inland State, and, not being in condition geographically to ask the Government for aid to be applied as other and older States do, it does not seem presumptious or extravagant to ask for aid and assistance for a system of irrigation which, when carried out faithfully, honestly, and conscientiously, will people its confines with American citizens, and will create homes for the progeny of American citizens in a land where only educated labor and a pride in American institutions are required to make the most prosperous and happy people on the face of the globe.

Finally, we have endeavored to show that there is in this State a large body of irrigable agricultural land, and that there is ample available water within the borders of the State, if properly stored and used, to irrigate this land.

The foregoing is respectfully submitted for your consideration by the Nevada State Board of Reclamation and Internal Improvement.

EVAN WILLIAMS, *Chairman*,
J. R. BRADLEY,
L. A. BLAKESLEE,
HERMAN SPRINGMEYER,
Commissioners.

T. D. EDWARDS,
Secretary.

STATEMENT OF W. L. FULTON, OF RENO.

The CHAIRMAN. Have you a prepared report?

Mr. FULTON. Yes. I represent a commission consisting of five members of Washoe County. Fearing that we would not have an audience, we had it printed. There is some data in the report, and it contains such facts as we thought would be appropriate. We have not taken section by section and given the detail of the reservoir sites in the mountains; but we have prepared a map that shows the headwaters of the Truckee and the irrigable portions of our county, as well as the ditches that have been constructed.

The report is as follows:

GENTLEMEN: The board of commissioners of Washoe County, with a patriotic desire to afford you every assistance possible, has selected five of her citizens to welcome you to our State and impart any information we have, and fearing that the uncertainty attending your movements and the pressure upon your time might prevent a personal attendance, we take this method of extending to you the freedom of our county and town, and inviting you most cordially to spend any time at your command with us in a closer study of the problem you have in hand; and, while we take great pleasure in extending a cordial welcome to the distinguished members of your committee and to the eminent gentlemen in your company, permit us to hope that the slurs cast upon us, as a State, by the dismal funny men and political Pharisees, have not caused you to come among us asking the ancient question modified—"Can any good thing come out of Nevada?" Like Nazareth of old, our State is held to be extremely common by the more esthetic and wealthy portions of the nation, but we believe it can be shown to you that while no State or Territory is poorer or more neglected now, that not one of them will receive the relative benefit from your labors that Nevada will. It seems almost providential that such great bodies of fine land can be found lying immediately under the immense natural and possible reservoirs of the Sierras, and any adequate plan of water storage and for bringing water and land together will do more for Nevada, in all that goes to make a State, than can be done for any other part of the arid region.

As you have already ridden *through* the State from east to west, we need not say that *Nevada needs irrigation. With* our scanty rain-fall of 5 or 6 inches we are lim-

ited to a very small area for agriculture or pasture, but with sufficient water storage we can cultivate a large portion of our State. The great American desert is a desert only because it is dry, for its soil is good and its climate unsurpassed. Nevada contains about 109,000 square miles, of which less than 3 per cent. can be used by the present water system, and about 33 per cent. if water could be provided. We can not expect much from artesian wells, for experience is against us. There are a few shallow wells in the State, but no deep ones have been found, and none at all capable of irrigating more than a few acres. At Battle Mountan several are down about a hundred feet, but they are only valuable for gardens. One or two near the State line would be useful for watering stock, and a number are found just across the border in California, flowing from five to ninety gallons a minute. A few years ago a well was sunk by the railroad company to a depth of 2,346 feet at White Plains, the lowest point on their line in the State, but it ended as dry as it began. Previously one at Lovelocks, over 1,000 feet deep, had met with failure, as did others in widely separated portions of the State, so that we may say that Nevada's future growth depends solely upon the use of her opportunities for water storage. That she is worth reclaiming is very easily proven. No more delightful place to live can be found upon the continent; no part of America has so many days of sunshine with delicious evenings and nights of comfort; no corner of the Union has the freedom from malaria, consumption and kindred diseases, and in no State is agriculture pursued with greater ease or larger profit. The farmer is certain of his crop, as well as of his market. Ready sale can be had for all that can be raised. His hay is all needed for keeping the fat beef gathered off the ranges in fit order for the city markets, and in supplying mining, milling, and stage stock; his grain is taken at the mills the moment it is ready to be sold, at market prices, freight added; his fruit is absorbed as soon as it is ripe in preference to the imported article, and all the products of his industry net him in cash better prices than can be realized almost anywhere else in the civilized world.

Nor is nature stingy either in the quantity or quality of her bounty. With a warm sun and a certain supply of moisture there can be no failure. The constant stream is loaded with liquid fertilizers gathered along its way and sinks with them down to the roots of the tree or plant, producing a rapidity and perfection of growth absolutely astonishing. Whatever grows here grows to the limit of quality. The wheat, in grain and straw, is as clean as the gold from the mine. The potato is a sealed package of white meal, the apple is the best of its species. In addition to all kinds of grain and grasses Nevada is particularly well adapted to the apple, the potato, the plum, and the pear, besides all small fruits and berries, while certain kinds of grapes grow to perfection. But we claim the superlative in apples, potatoes, and wheat; and to prove our claims the product of our soil bore off the prizes at New Orleans and other great fairs.

Some idea of the capacity of the State can be gained from studying our own county of Washoe, which raises yearly 60,000 tons of the best kind of hay, besides wheat and other grains. It seems especially well adapted to alfalfa or lucern, as it is known to Americans, which grows luxuriantly but does not grow to woody stalks as it does in California. As well, however, as our fields and farms look to the traveler, in contrast to the sage-brush stretches, they do not take in our best lands. They have been chosen by the settlers because they lie nearer the streams and can be reached by ditches at less expense, but the higher benches and valleys, stretching for miles, have a soil superior in strength and quality, and freer from rock and alkali. While the lower lands have been covered with water during the glacial or some later period of high floods, carrying off much good loam and leaving the land covered with rocks and bowlders, the lands beyond were being formed by rich sediment, and the ground can be reclaimed and irrigated by simply burning off the brush. Millions of acres of such land in Nevada are only waiting for the water to enrich the hands that may till them.

The map which we file with your engineer will give you a good idea of what has been done in Washoe County by individual enterprise. The lines of ditches which you will see thereon have been dug by single individuals engaged in farming the land covered, or by half a dozen combined, and in no case has such an undertaking been put through by moneyed men for the sake of the investment. All this vast outlay of time and strength has been made by the hard-fisted sons of toil, who labored often with a rifle at hand to stand off hostile Indians, and who deserve as much credit and consideration as the Puritan fathers or the Kentucky pioneers. Beyond these ditches, however, lie not only the best of our lands, but by far the larger portion.

At least a quarter of a million acres of the best of land could be reclaimed in Washoe County alone, and put to producing crops right where the farmer can get the highest prices, enjoy the best climate, live near good schools and churches, and have all that man needs to be comfortable and happy. We have the land and we have the water, if it could be saved. An ocean runs to waste every spring, and goes out into the hot desert to be absorbed by the dry and thirsty air. In the grand background

which rises to the west you can find abundant opportunities to save the floods. One class of reservoirs is the natural lakes—Donner, Webber, and Independence—which have extensive water-sheds extending right up to the eternal snows of the summits, that send down floods sufficient to raise them 20 feet. Lake Tahoe, however, is the great hope of Western Nevada, and one foot put on its surface would equal all the other lakes combined. It has 175 square miles, with a water-shed capable, in ordinary years, of raising it 8 or 10 feet, and an outlet which can be perfectly controlled by a timber dam with wooden gates, worth a few hundred dollars. Another system of lakes which will be extremely valuable can be made by taking the hundreds of mountain meadows, which abound in the Sierras, and closing the mouth of each with a dam. They are used now for summer dairies by parties who winter in California, and though many of them are owned, none are improved to any extent. For about five months in the year they are occupied and the rest of the time they are left to be filled from 5 to 40 feet deep with snow. They are from a few yards to a few miles in extent, and have all the materials for dams on the ground. We regard these as next in importance to Tahoe and the other natural lakes. Many of them have large water-sheds and a good supply of water, with excellent dam sites at their outlet.

Another excellent proposition would be to divert waters from their beds during flood tide and hold them in favorable places, large or small, until needed. A great many very good-sized lakes could be thus kept full, and the work of walling them in on one side would not be expensive. They would be especially popular with parties near the foot-hills, who could use them as adjuncts each to his own farm. The opportunity for this class of works is limited only by the amount of money that can be controlled, and in time they will dot the map by hundreds and thousands. This system of tanks, as they are called there, has done very much to feed the swarms of people in India, and in time will many times double our capacity for supporting population. The mountain reservoirs, however, will always have one great advantage in the way of evaporation. In the central and eastern part of the State this amounts to from 70 to 90 inches, while it must be much less in the cooler and higher regions. A number of very useful reservoirs could be created by damming up the Humboldt, Carson, Truckee and other rivers at favorable places and flooding level valleys behind. The lands which in such cases would be covered are now very generally farmed, and on some are large and important towns, crossed by railroads in some cases, and it would be a matter of calculation whether any of them would be worth more as reservoir sites than for present purposes. Up in the mountains are Prosser Creek, Little Truckee, and other large streams with sufficient water-sheds and many excellent reservoir sites to form lakes many miles in extent.

Now, gentlemen, we believe that with our mild but invigorating climate; with our extensive valleys and benches of good land extending in convenient locations, from high up the mountain sides down to the lowest altitudes in the great basin on the one side and our unsurpassed possibility for water storage on the other, that we can offer more solid and substantial return for every dollar put into engineering works than any other part of the West. For the first time in its history, the Anglo-Saxon race has undertaken to reclaim a desert. All our blood and kin have had to contend with too much instead of too little water, and make laws to regulate drainage instead of irrigation. Our sturdy forefathers drove their weaker neighbors down on the dry lands of France, Spain, and Italy, taking the well-watered portions for themselves. And when we come to apply their theories to this arid region they fail to work. Coming thus handicapped to the task, our water suits have been costly, tedious, and embarrassing. Contests, murder, oceans of perjury and other crimes have been but part of the evil results of the national mistake of applying old ideas to new conditions; but at last a start, at least, is promised and the work is being intelligently investigated by the only power that can handle it. You must be convinced that the task of reclaiming this vast region has gone as far as it can in this way and, indeed, as far as it should. A point has been reached where it becomes the duty of the national Government to take the matter in hand, and permit us to say, that since its formation it has had no higher or nobler opportunity. You are engaged upon the grandest work of this century; no political event of a hundred years equals in importance the making of homes for thrifty and intelligent millions over two-fifths of the United States. The time is coming when large classes of American citizens will be found asking, not where can I go and make money, but where can I go and eat? Where can I go and earn a living for my family? The answer will depend, we believe, very largely upon your conclusions, and upon your report and recommendations to the Senate. We await in breathless anxiety the result. If it be announced as the policy of our Government that no aid shall be extended to the struggling settlers who are giving their whole lives to the work of fitting these sage-brush deserts for homes for future generations; if the policy of the past few years is maintained, by which surveys are discontinued, leaving large tracts without township or section lines; if patents are withheld and the privileges of settlement hedged about with technical obstructions, then Nevada,

at least, has a barren future and many people will have to go elsewhere for the means of life. But we do not believe such a policy can find favor in your enlightened minds. We believe the Anglo-Saxon needs no example from Mexico, Spain or Lombardy, but will find in itself the intelligence, virtue, and grit to conquer this land as it has every country where it has ever set its foot. We believe that no higher duty or more precious privilege has ever been assigned to a nation, and it is the grandest office a Government of the people, by the people, and for the people can ever have.

R. L. FULTON.
T. V. JULIEN.
JAMES MAYBERRY.
T. K. STEWART.
C. H. STODDARD.

RENO, NEV., *August* 19, 1889.

The CHAIRMAN. You may give an explanation of the map you present.

Mr. FULTON. We start with a part of Lake Tahoe, a part not being in our county. On the summit of the Sierra Nevadas the snow-fall is one of the largest known in the world. The Truckee leaves that point [indicating] and is 90 miles long. It runs into Pyramid Lake, and it falls gradually all the way from this point [indicating]. About 3 miles above Verdi a series of benches set in, and ditches have been begun at that point. We have ditches already constructed in our county covering 50,000 acres of land. There are in all about 25 ditches.

I would like to say in connection with these ditches that every one of them has been constructed by private enterprise, not one by capital for the sake of investment. A great many of them have been constructed by men with their rifles at their sides to keep off hostile Indians and they are as much entitled to respect as the Puritan fathers.

The land above these ditches [indicating] is the best land. That below them is the land that was washed in the river channel a great many years ago, and it has left the bowlders and everything like that to be removed before the land can be irrigated. But above these ditches, in this valley, you can hardly find a rock without it is on a little ridge.

The natural lakes, Weber, Independence, and Donner, have full water-sheds, extending right to the summit of the Sierras, and receive a steady flow from the snow banks which will raise them 18 or 20 feet a year. But the great resource of western Nevada is Lake Tahoe, which has 175 square miles of surface, and a total water-shed of 400 miles. capable of raising it 6 or 7 feet a year. The outlet is narrow and can be controlled by a cheap timber dam with wooden gates, the whole thing costing only a few hundred dollars. Such a dam is already in operation, holding back the spring floods. The mills at Truckee draw from it, and they only shut the gates when there is more water than is needed for their purpose. Last winter about 17 inches was saved, and the previous year more.

A very important class of reservoirs can be created by damming up the water in the hundreds of mountain meadows which are found in the Sierras. They are used as dairies now by people who drive up their cows from the Sacramento Valley in the spring and back in the fall. They are inhabited fully five months of the year, and the balance of the time are left to be filled with from 5 to 40 feet of snow. Materials for building dams are now on the ground, and the water-sheds are generally large enough to create good sized lakes from a few rods to a few miles in extent.

Another class of reservoirs could be created by conducting the water *from* its natural channel to places where, by building a wall on the lower *side of a flat* or cañon, tanks, as they are called in India, can be made

They form a valuable supply to the acres of an immense population there, and in time will dot the map by thousands. The only limit to them will be the amount of money to be had.

Another class could be made by damming up the Truckee, Humboldt, Prosser, and other streams at favorable places, flooding flats behind. On all these streams are flats or beds of former lakes, which can be reserved and used for reservoirs. Some of them are inhabited and farmed and in some are found towns and villages, and it would be a matter for calculation as to whether such would be worth more for reservoirs than for present uses.

The CHAIRMAN. Leaving out Tahoe, suppose the water that comes from the other water-shed were equally well economized, how much land could be irrigated with it?

Mr. FULTON. I think with the water saved up we could irrigate all the land in our country, all the north side of the Truckee River.

The CHAIRMAN. About what percentage of the Truckee is now used?

Mr. FULTON. I do not think we use over 2 per cent. of the Truckee River.

The CHAIRMAN. Taking the flow for the year?

Mr. FULTON. Season after season, for the year round. I think the balance goes to waste.

The CHAIRMAN. Take Washoe, for an example. To what extent can the population be increased and the land reclaimed by small irrigation works?

Mr. FULTON. We have found very little help from any investment as an investment.

The CHAIRMAN. If the facts were made known by surveys, to what extent would the land be reclaimed? Is it in the reach of an ordinary association of farmers?

Mr. FULTON. If the Government stood in the position of Divine Providence, and could increase the flow in these ditches, the ditches would be built by private enterprise. I am not so certain about the reservoirs. If the reservoirs were built and the water turned into these natural streams, it would be a different proposition to build a ditch. But I am not prepared to answer what the disposition of our people would be toward saving the water.

The CHAIRMAN. Suppose settlers should come in here to make homes, how much of this work is within their reach without the aid of accumulated capital, the facts being known?

Mr. FULTON. We do not know to what extent they want to come.

The CHAIRMAN. Suppose they wanted to come very much?

Mr. FULTON. They could come and make homes, but I do not think they could make homes in much less than two or three years.

The CHAIRMAN. If intelligent settlers should come here with the intention of going to work, they could find fine opportunities for constructing reservoirs and storing water to reclaim land?

Mr. FULTON. Yes.

The CHAIRMAN. At what cost?

Mr. FULTON. About $10 an acre.

The CHAIRMAN. What would be the value of the land when reclaimed?

Mr. FULTON. Sixty dollars, I think. I think in Lehman's Valley there is good land, no better on the face of the earth. There they could go and build a ditch and make homes for a thousand persons.

STATEMENT OF B. F. RILEY, OF HUMBOLDT COUNTY.

The CHAIRMAN. What is your occupation?

Mr. RILEY. I am assessor of Humboldt County. I have no regular report. I have simply facts and figures. I will file this paper, and after having done that, I do not think it is necessary to make any further remarks.

Senator JONES. What is the paper which you wish to file?

Mr. RILEY. It is in regard to the storage of water, and the land to be cultivated.

Senator JONES. Is it your own individual expression of opinion on the subject, or is it prepared by some society or association?

Mr. RILEY. It is made by me as assessor of Humboldt County, of this State. I am appointed by the county to make this report.

Senator JONES. Then it is a paper of your own production?

Mr. RILEY. Yes.

The paper is as follows:

The principal valleys of Humboldt County, Nev., are Quinn River Valley, Paradise Valley, including Little Humboldt, Clover Valley, including Kelly Creek, and the Humboldt Valley, including the Big Meadows. Their area in square miles is as follows:

Quinn River Valley, 750 square miles.

Number of acres of land, 480,000.

Acres now in cultivation and irrigated, 15,000.

Number of acres uncultivated, 465,000.

Number of streams flowing into the valley, 8.

Volume of water flowing into the valley during the months of March, April, and May, 40,000 miners' inches.

Amount of water required per acre, 1 miners' inch.

Time required each year to irrigate land, 30 days.

Amount of water required to irrigate present amount in cultivation each year, 15,000 miners' inches.

Surplus water for thirty days each year, 25,000 miners' inches.

Amount of water running to waste each year for sixty days, 40,000 miners' inches.

Amount of land that could be brought into market and placed in cultivation by the storage of water, 65,000 acres.

Streams on which large amounts of water could be stored to great advantage: Quinn River and McDermit Creek; smaller amounts of water could also be stored on Eight Mile Creek, Flat Creek, Willow Creek, Rebel Creek, and Buffalo Creek, on Quinn River. Two dams 100 feet long and 25 feet high would back water over at least 200 acres of land; one dam on McDermit Creek, 40 feet high and 200 feet long, would back water over 300 acres of land.

The area of square miles of Paradise Valley and Little Humboldt is 400.

Number of acres of land, 256,000.

Amount of land in cultivation, 60,000 acres.

Amount of water flowing into valley during March, April, and May, 60,000 miners' inches.

Amount of water required to irrigate present amount of land in cultivation each year for thirty days, 60,000 miners' inches.

Amount of water running to waste for sixty days each year, 60,000 miners' inches.

Amount of land that could be brought into market and cultivation by the storage of water, 120,000 acres.

Streams on which water could be stored: Little Humboldt River, Martin Creek, and Cotton Wood Creek. On the Little Humboldt River a dam 50 feet high and 100 feet long would back water over 2,000 acres of land. A dam on Martin's Creek 100 feet long and 50 feet high would back water over 500 acres of land. Two or three small dams on Cotton Wood Creek would store large amounts of water. There are a number of other streams running into the valley where water could be stored.

The area of square miles in Clover Valley and Kelly Creek is 125, about 80,200 acres. There are in cultivation 8,000 acres.

There are three good-sized streams running into this valley on which water could *be stored, which* would bring into market and cultivation several thousand acres of *productive land.*

The area of the Humboldt Valley, including the Big Meadows, is 400 square miles, or 256,000 acres.

There are in cultivation in this valley 50,000 acres.

There are in the Big Meadow Valley alone 227,000 acres, of which there are in cultivation and irrigated 20,000 acres, leaving a balance of uncultivated land in this section of the valley of 207,000 acres, which could by the storage of water be brought into market and cultivation. The Humboldt River flows through the whole length of this valley with a flow of 144,000 inches of water during the months of April, May, and June, and, as this water is not used for irrigating purposes before the middle of April, large amounts could be stored for irrigating purposes later in the season. There should be at least three reservoirs built on the river between Oreana and Humboldt stations. These dams or reservoirs should be from 6 to 8 miles apart. There are points on the river that dams from 200 to 300 feet would span the river, and dams 25 feet high would back the water in the river 6 or 8 miles, and would cover at least 3,000 acres of land, and would hold sufficient water to irrigate at least 150,000 acres of land, which would produce 60 bushels of wheat or barley to the acre, or 6 tons of hay per acre each year.

There are many other small valleys in the county where water could be stored to great advantage and good agricultural land reclaimed and brought into cultivation and good crops produced.

STATEMENT OF R. G. WHEELER, OF PARADISE VALLEY.

The CHAIRMAN. What have you in your hand?

Mr. WHEELER. This is a paper prepared at a meeting of the people of Paradise Valley.

It is as follows:

PARADISE VALLEY, NEV., *August* 10, 1889.

In pursuance of the request of Surveyor-General Jones for representatives from the different committees to meet with the Senate Committee on Irrigation at Carson, and in accordance with the resolution of the county commissioners of Humboldt County, the people of Paradise Valley, Humboldt County, in mass-meeting assembled, unanimously passed the following resolutions:

Resolved, That we earnestly request the aid of the General Government to build reservoirs for the storage of waters passing in large quantities through the creeks and streams of Paradise Valley in the early part of the season, which if stored would be sufficient to reclaim thousands of acres of productive soil now utterly useless.

Resolved, That in the opinion of this meeting if the natural facilities for the storage of water in this valley were taken advantage of the population instead of decreasing would be greatly increased and more prosperous.

Resolved, That if the waters of the Owyhee River were diverted so as to empty into Dry Cañon, from whence they would pass into the Little Humboldt River, it would result in the reclaiming of many thousand acres of land in the lower end of Paradise Valley.

Resolved, That R. G. Wheeler be appointed to represent the interests of our people before the Senate Committee on Irrigation at Carson, Nebr., August 15, 1889.

P. M. PALMER,
President of Meeting.
R. G. WHEELER,
Secretary.

STATEMENT OF JOHN O'KANE, OF BIG MEADOWS.

The CHAIRMAN. Have you a written report?

Mr. O'KANE. No; I have not a report, but a petition. This is a petition from the citizens of Big Meadows, in Humboldt County. It was handed to me to present to the committee.

Senator JONES. Can you state the contents of the petition?

Mr. O'KANE. I have not read it; but it sets forth the condition of the people of that section at the present time. The country there is very dry, and the people of that locality are suffering a great deal from the drought.

The petition is as follows:

LOVELOCK'S, *August* 1, 1889.

To the honorable the Senate Committee on Irrigation and Water Storage:

SIRS: Your petitioners would respectfully represent that—

Whereas in the year 1875 in this section of Humboldt County, namely, Big Meadows, there was practically no acreage of land under irrigation or cultivation; and

Whereas there are now cultivated by the use of natural waters in irrigation about 9,500 acres; and

Whereas there still remains a large area, that is about 250,000 acres, which with proper use of the surplus waters of the Humboldt River could be profitably tilled and produce a great variety of crops; and

Whereas there annually runs to waste within said county a very large quantity of water and enough to irrigate the whole of said 250,000 acres and more; and

Whereas there are along and adjacent to the natural streams within this section eligible sites for reservoirs and other means of water storage; and

Whereas we earnestly believe that a fair inspection of this section would show that it offers prime reasons for investment of private or public funds for such works: Now therefore,

We, the undersigned, do respectfully request and urge that your honorable committee do submit said county and this section either to inspection personal or through your representatives, as we believe the same will result in the discovery of great natural resources, and the building up of permanent and prosperous communities within the county of Humboldt.

The meeting at which these resolutions and requests were authorized will cause to be made all suitable preparations upon notice for your courteous reception and the lightening of your labor in all possible ways.

Your petitioners conclude by praying for your early and favorable response hereto.

W. C. Ruddell, chairman; H. C. Marker, John Harrison, D. S. Baker, F. X. Banks, D. D. Grannis, J. C. Damm, C. Bastian, S. B. Smart, P. N. Marker, L. F. Herrod, J. Rouge, S. Billups, George Keating, Ed. M. Emmons, R. Akers, Robt. Reed, Geo. McKenzie, Navore Walle, Lewis Rees, G. W. Ladd, N. Nelson, J. Damm, W. F. Randolph, S. R. Young, Peter Anker, Jos. Marzen, A. Westfall, John Hill, M. Metcalf, Geo. Lovelock, sr., N. P. Dann, L. L. Downs, John Clary, L. G. Metcalf, P. A. Ostrander, John Ryan, W. P. Smith, A. Olson, John O'Kane, P. K. Reid, H. F. Martin, Paul Reid, L. N. Carpenter, L. M. Donelin, Joseph Hill, Antone Feliz, B. F. Grosser, Geo. Young, J. H. Thies, J. T. Hauskins, Eugene Cozzens, G. W. Tavener, Emmet Reid, J. T. Reid, Geo. Singer, A. Hull, J. C. Bestbright, H. J. Bender, T. P. Esberg, D. L. Davies, Phill. Skewes, J. Barker, Jesse G. Welch.

The CHAIRMAN. You are a farmer in Humboldt County?

Mr. O'KANE. Yes; I have been farming there for twenty years.

The CHAIRMAN. What is the character of the crops you raise?

Mr. O'KANE. The character of the crops is chiefly, barley, wheat, potatoes, and alfalfa.

The CHAIRMAN. Is the land suitable for all kinds of crops?

Mr. O'KANE. It is suitable for all kinds of crops that can be raised in the northern or central States.

The CHAIRMAN. Do you raise fruits?

Mr. O'KANE. We do not raise much fruit. It is only within the last few years that we have planted fruit-trees; but the trees are doing well, though they are not old enough to bear fruit; they are experimental thus far.

The CHAIRMAN. What kind of crop of alfalfa do you raise?

Mr. O'KANE. Six tons a season; but much more has been raised.

The CHAIRMAN. What would be a good crop of potatoes?

Mr. O'KANE. We raise from 250 to 300 bushels to the acre. The soil is particularly adapted to the raising of potatoes.

The CHAIRMAN. How about beets?

Mr. O'KANE. We have very few beets; I have seen beets grow there, though, sugar-beets. I have seen them grow there so large that they would weigh 12 pounds each.

The CHAIRMAN. What is a crop of wheat in your section?

Mr. O'KANE. We can produce from 45 to 50 bushels to the acre; on an average.

The CHAIRMAN. And how with regard to barley?

Mr. O'KANE. I have seen wheat produced 100 bushels to the acre; of barley we raise 50 bushels to the acre.

The CHAIRMAN. How about oats?

Mr. O'KANE. Eighty to 90 bushels.

The CHAIRMAN. But you have a deficiency of water there now?

Mr. O'KANE. Yes; we are drier this year than ever before.

The CHAIRMAN. In the Humboldt River in good seasons, what volume of water comes down? Have you paid attention to that?

Mr. O'KANE. I can not state the number of inches in ordinary years in the Humboldt; but I could give you a very good idea of what it is. The Humboldt River, where it enters Big Meadows, is about 100 feet wide, and in seasons when it is flowing an ordinary flow it will be from 12 to 15 feet deep. I think it will flow about 3 miles per hour. That is the current for flood season.

Senator JONES. I would like to ask about that wheat of which you spoke. Is it grown on irrigated land?

Mr. O'KANE. On irrigated land. The soil will not produce anything without irrigation.

Senator JONES. Was it ever tried on that land?

Mr. O'KANE. It may have been tried, but I do not think it produced anything without irrigation. They sow the wheat in the spring, and it comes up with a natural moisture, and then in May they irrigate once. That insures an excellent crop. The soil retains the moisture. It is a spongy soil, and it is easily moistened. It holds the moisture a long time.

Senator JONES. Without irrigation you can produce nothing?

Mr. O'KANE. Nothing at all. There has been plenty of water in former years flowing there to irrigate all the land we have in that valley.

The CHAIRMAN. You mean in the river bottom?

Mr. O'KANE. Yes; just at the head of the sink and around the sink.

STATEMENT OF J. H. THIES, OF LOVELOCK'S.

The CHAIRMAN. You are a farmer at Lovelock's?

Mr. THIES. Yes.

The CHAIRMAN. How long have you been there?

Mr. THIES. Eighteen years.

The CHAIRMAN. You heard what was stated by the gentleman who preceded you. Is that substantially your idea of the production of crops in this country.

Mr. THIES. Yes; there has been more raised than that, but what was stated is about the average.

The CHAIRMAN. How much land have you under cultivation?

Mr THIES. I have about 700 acres at Lovelock's at the present time. At Lovelock's there are about 10,000 acres under cultivation.

The CHAIRMAN. What do you say about the volume of the water running in the Humboldt in good seasons, at flood times?

Mr. THIES. What Mr. O'Kane said is true. It is about 100 feet wide and about 10 or 12 feet deep.

The CHAIRMAN. If the water were drawn out in flood times for the purpose of irrigating your 10,000 acres of land, would it have any perceptible effect upon *the river*?

Mr. THIES. No. In 1879 that lake went dry, as it is now.

Senator REAGAN. What lake is that?

Mr. THIES. Humboldt Lake. In 1882, after irrigating all the land there under cultivation, it was higher than ever before. So that shows there is an enormous amount of water that has gone to waste every spring except this spring.

The CHAIRMAN. From your observation can you state to what extent Humboldt Valley could be reclaimed, if the water above were stored in proper reservoirs and economized? Take the whole valley of 200,000 acres of rich loam.

Mr. THIES. Yes, and there are only about 10,000 under irrigation. We have about 500 population there now. With proper management of the water, I could not say to what extent.

The CHAIRMAN. Give your observation.

Mr. THIES. It certainly would be a large percentage of increase. It would afford homes for quite a number of persons.

STATEMENT OF A. W. HESSON, OF ELKO COUNTY.

The CHAIRMAN. Have you a report?

Mr. HESSON. I have no report to present. I was not prepared to meet this committee. I was informally requested to come here.

The CHAIRMAN. You have assessed the county repeatedly, and are familiar with it?

Mr. HESSON. Yes.

The CHAIRMAN. Give a short description of the county and the land under cultivation, and state what are the chances for the cultivation of more land, if any?

Mr. HESSON. We have at present in Elko County some 60,000 acres, or thereabouts, under cultivation; that is in various crops. That, by the storage of water, could be increased four or five times with a small outlay of money in different places.

Senator JONES. In your judgment, if the water were saved to its utmost capacity, how much land could you have under cultivation?

Mr. HESSON. It is safe to say that we could have from 250,000 to 300,000 acres.

Senator JONES. Then you mean four times as much?

Mr. HESSON. Yes; four times.

The CHAIRMAN. Describe Squaw Valley.

Mr. HESSON. In Squaw Valley we have storage, but I am not prepared to say the number of acres the dam covers, but it holds sufficient water to irrigate 2,000 acres—something in that neighborhood, and it can be increased so that it will irrigate 4,000 acres. That is working successfully at the present time.

The CHAIRMAN. Describe the streams that are tributary to it.

Mr. HESSON. The principal one is what is called Willow Creek, a mountain branch of water, and water is stored at its head.

The CHAIRMAN. How much water would there be in it at the irrigating season if there were no dam there?

Mr. HESSON. I do not think there would be any land irrigated at that point.

The CHAIRMAN. It is entirely artificial?

Mr. HESSON. Yes; there was no land tilled in that vicinity until this dam was built.

The CHAIRMAN. Could the water have been taken out or the land *tilled without* the dam?

Mr. HESSON. No. The water went off in the flood season, in the spring of the year.

The CHAIRMAN. Are there abundant or quite extensive opportunities for similar dams in Elko County?

Mr. HESSON. Yes; there are quite a number of places where similar dams could be built, and larger ones. The reservoirs are greater than at this place, particularly on the North Fork of the Humboldt, and also on the South Fork.

The CHAIRMAN. What are the products they raise by this dam in Squaw Valley?

Mr. HESSON. They have been principally of alfalfa. They have raised wheat and barley.

The CHAIRMAN. Whatever they have tried to raise they have been successful in?

Mr. HESSON. Yes; they have been successful in raising grain.

The CHAIRMAN. What is the average crop in Elko County?

Mr. HESSON. In this particular place it has been an average of 45 bushels of wheat to the acre.

The CHAIRMAN. And other cereals in the same ratio?

Mr. HESSON. The oats would go away up into the sixties. That would be an average, though they go higher than that.

The CHAIRMAN. How much alfalfa?

Mr. HESSON. Five tons.

The CHAIRMAN. What are the principal localities? Are there any?

Mr. HESSON. Ruby Valley is an extensive farming country. They raise wheat and barley principally in that valley. That is not quite as productive as this other valley. It is colder, and the crops are not so certain. Clover Valley is right across the mountain from Ruby, immediately east from the first-named valley.

Senator JONES. What was the cost of that dam in Squaw Valley?

Mr. HESSON. What I have been informed is that it was in the neighborhood of $100,000—something less than that, but in that neighborhood.

The CHAIRMAN. Then water is carried from that main ditch to the land that is irrigated?

Mr. HESSON. Yes.

The CHAIRMAN. Have you any idea of the cost of that ditch?

Mr. HESSON. No; I have not, of the first named ditch. It is a ditch some 10 miles in length, and about an average depth of 2 or 3 feet.

The CHAIRMAN. You have some idea of its approximate cost.

Mr. HESSON. The approximate cost of that dam is in the neighborhood of $8,000.

The CHAIRMAN. The dam, as at present constructed, will retain water enough, you think, to water 4,000 acres, or would there have to be additional work done to reclaim 4,000 acres?

Mr. HESSON. I think the dam will hold sufficient water to irrigate 4,000 acres. It has been enlarged. That was done a year ago, and since the enlargement there has not been water enough to fill the dam.

The CHAIRMAN. You think that 4,000 acres is the capacity of the present works?

Mr. HESSON. Yes.

The CHAIRMAN. And since the enlargement there has not been water enough to fill the dam?

Mr. HESSON. No; not since it was completed? It was raised 15 feet.

The CHAIRMAN. Then there is a cost of $20 for every acre under it to be cultivated?

Mr. HESSON. Yes.

The CHAIRMAN. Is that the average cost of the storage works which you think might be inaugurated through that country? Will they all be as costly per acre as that?

Mr. HESSON. No, I think not. I think dams can be constructed for much less per acre than that has cost. This was an experiment. The first dam that was built on this side was washed out. The parties were inexperienced.

The CHAIRMAN. Do you include in that $100,000 the cost of the washed-out dam?

Mr. HESSON. Yes.

The CHAIRMAN. What do you suppose the present dam cost?

Mr. HESSON. I do not think the present dam has cost over half that, outside of the ditch.

The CHAIRMAN. Have you any information in regard to the cost, except what you have heard on the outside?

Mr. HESSON. No, I have no reliable data on this matter.

Senator JONES. You think other land could be reclaimed at less expense? If your estimate of the cost of the present dam is correct, that would make a cost per acre to the land that could possibly be reclaimed by this ditch $12.50. Do you think there are other lands in the county that could be more cheaply reclaimed than at a cost of $12.50 per acre?

Mr. HESSON. Yes, so far as the water storage is concerned.

Senator JONES. What is your idea of the average cost of storage per acre under the eligible locations for dams in your county?

Mr. HESSON. I do not think the average cost would be less than that. In certain localities it would be less, and in others it might be greater.

STATEMENT OF CHARLES W. IRISH.

The CHAIRMAN. Are you familiar with Squaw Valley dam and its cost?

Mr. IRISH. Yes; I visited it last week.

The CHAIRMAN. State the facts in regard to it.

Mr. IRISH. In regard to the cost of the dam it was in round figures $40,000. So I was informed by the person who constructed it.

The CHAIRMAN. That is the first dam?

Mr. IRISH. No; the present dam.

The CHAIRMAN. What was it about the one that was washed out?

Mr. IRISH. I do not know anything about that.

The CHAIRMAN. How much land is irrigated?

Mr. IRISH. They have the greater part of three sections under cultivation from the water stored by that dam.

The CHAIRMAN. If the dam were filled with water, how much land would it cover?

Mr. IRISH. It would furnish water enough for the irrigation of six sections of land throughout the crop season. That is its calculated capacity.

The CHAIRMAN. That dam never has been filled since it was raised?

Mr. IRISH. No; except once just after the spring season. Then it was filled. It was completed only last year, and this dry season has prevented it being kept full of water this year.

The CHAIRMAN. How much water shed is tributary to that dam?

Mr. IRISH. I think somewhere between 14 and 20 square miles. I *am not quite* certain about that.

The CHAIRMAN. What is the effect of irrigation upon land, what is the quantity of water required, the most water, and can the amount of water necessary to irrigate the land be reduced as time progresses?

Mr. IRISH. It requires most water to produce the second crop of hay.

The CHAIRMAN. Which year can you do the most with the same quantity of water, the first or second year?

Mr. IRISH. I think the first year's crop of well-cultivated land would be the largest.

The CHAIRMAN. As to the quantity of land. At what time do you reach the maximum of the amount to be irrigated?

Mr. IRISH. That depends altogether on the quality of the subsoil. I think the effect of irrigation is to improve the porous soils. Where the subsoil is porous it requires the most water the first few seasons of croppage. But I notice that as the seasons pass on and the water is brought on to the land it closes up the porous soil and causes it the better to retain the water. But the clay subsoil will remain the same from year to year. That depends altogether on the porosity of the subsoil.

The CHAIRMAN. Have you traveled over the State?

Mr. IRISH. I have traveled generally over the State.

The CHAIRMAN. What is the general condition of the southern portion of the State, as to arable lands, valleys, and water?

Mr. IRISH. The general condition as to tillable lands, I would state in plain English, is a condition of neglect.

Senator JONES. Do you mean the lands under cultivation?

Mr. IRISH. I mean to say that they are neglected.

Senator JONES. You mean the lands under cultivation have not been properly cultivated?

Mr. IRISH. Not in all cases.

The CHAIRMAN. What are the opportunities there?

Mr. IRISH. The opportunities are wide. I think there are more tillable lands to the townships toward the southern part of the State than in the northern parts. There is a greater spread of tillable land in the southern half of the State.

The CHAIRMAN. Have you ever been over Lincoln County?

Mr. IRISH. You might say I have been over half of Lincoln County.

The CHAIRMAN. Extending your observations there, what do you say of Lincoln County?

Mr. IRISH. I think Lincoln County is the best county in the State, so far as agriculture is concerned. It has a greater range of products than any other part of the State. In Lincoln County can be raised any of the crops that can be raised in the Gulf States. They can raise corn, cotton, and sugar cane.

The CHAIRMAN. You have the land and the water there to do it?

Mr. IRISH. We have the land and the water. We have large quantities of both; it simply requires some system to bring the water on to the land to produce the crops.

The CHAIRMAN. What would you say of Lincoln County, if a population of settlers should desire to occupy it? Are the opportunities there within the means of an ordinary association of settlers?

Mr. IRISH. I think they are.

The CHAIRMAN. What opportunities are there in that section of the State for settlers to come in and make homes at a reasonable cost, if they knew the facts?

Mr. IRISH. Settlers in Lincoln County could more readily bring land

under cultivation than in any other portion of the State. The opportunities there are greater to that end, and at a less expense.

The CHAIRMAN. If surveys were made by the United States and the facts were shown, would it be possible for emigrants to avail themselves of the information thus obtained and make homes in that section of the State?

Mr. IRISH. Oh, yes.

The CHAIRMAN. To what extent?

Mr. IRISH. I think that there are not less than 60,000 acres of land in the portion that I have in mind that could be brought under improvement by a system of storage reservoirs for supplying the water for the purpose.

The CHAIRMAN. At what expense per acre? Did you figure on that?

Mr. IRISH. No; I have not figured on it particularly. But the cost of supplying water there would be less than in this part of the country, for the reason that it would not have to be carried so far. The necessity for long ditches would not exist there.

The CHAIRMAN. Are there high mountains in that section and sufficient snow-fall?

Mr. IRISH. There are high mountains; but the snow-fall is not so good as in this part of the country. All the rain and snow-fall there occurs in the winter season, the temperature going down to 20 degrees below zero. We consider that winter is the time for planting crops. There is no frost there to interfere.

The CHAIRMAN. You can start your crops then?

Mr. IRISH. The time they do plant their crops is in midwinter.

Senator REAGAN. Are the seasons long enough for cotton and sugar to mature?

Mr. IRISH. They have raised cotton there. I am satisfied that cotton was raised there for centuries previous to this time. I have seen bunches of cotton taken out of the burial places of the ancient inhabitants of that country. The burial places are the only traces left of them. I have cotton taken out of the crevices of the rocks.

Senator REAGAN. Is the season long enough for the sugar cane to mature?

Mr. IRISH. Yes, they have successfully planted and matured sugar cane there.

Senator JONES. Was this cotton of which you speak the seed or picked cotton?

Mr. IRISH. It was nice clean cotton. The manner in which they stowed away the remains of the dead was putting the bones in an earthen jar and then packing cotton all around them, and that cotton came out fresh, clean, and white. I think in a week I could bring you a specimen of the cotton.

The CHAIRMAN. I wish you would furnish the committee a specimen of the cotton you find. Are there other evidences that this country was inhabited by people who had some civilization?

Mr. IRISH. Yes; these people, whoever they might have been, lived in aggregated colonies. Wherever they could procure the water they irrigated the lands, as the lands will have to be irrigated now if they are to be successfully cultivated. Those people left the marks of their irrigation works on the soil.

Senator JONES. Are the marks of those works there now?

Mr. IRISH. Yes; they had a system of storing water, not as we would, by going into the mountains and building a dam, but they brought *water* down in canals, in a bowl shape right to the plain, and there *used it.*

Senator JONES. Are any of those canals there now?

Mr. IRISH. I have seen two of them.

Senator JONES. What is the largest one?

Mr. IRISH. About 500 feet across, and the small one 350 feet.

Senator JONES. How were they constructed?

Mr. IRISH. They were built by taking round bowlders, rocks, larger than a man could handle with his hands, and placing them in the wall, well defined, with a nice curve on the inside, and the wall cemented by an adobe clay; and the wall was water-tight.

Senator JONES. Were they covered in any way?

Mr. IRISH. No, I do not think they were. They were open reservoirs.

Senator JONES. You agree with the gentleman who made a statement just before you that the cost of storing water in Squaw Valley would be about $12.50 an acre.

Mr. IRISH. I think that the work which they have done there might be considered the maximum of the work in this State. I will tell you why. The dam which furnishes the water is built low down on the slope, and the consequence is the canal bringing the water down to the ground, where it is used, runs on a very small grade, and for that reason the ditch carrying the water has to be made of a large size, larger than anywhere in the State. In order to carry the requisite quantity of water the canals must be made larger.

Senator JONES. That relates to the canals, not to the reservoirs.

Mr. IRISH. Yes.

Senator JONES. You agree with the gentleman who preceded you that the cost is $12.50 per acre.

Mr. IRISH. Yes, that would be about the cost. That reservoir will, I am satisfied, do as estimated by the contractor; that is to say, I believe that the reservoir will irrigate about five sections of land when in complete use.

Senator JONES. That would be a little over $12.50 an acre, 3,000 acres and the cost of the dam $40,000. The gentleman who preceded you stated that that was his impression. It seems you agree about it. He said the cost of the ditch to take the water from the reservoir to the land would be about $8,000. That would be an additional cost of between $2 and $3 an acre. Do you think that is reasonable?

Mr. IRISH. That is about right.

Senator JONES. What is the land worth—a fair market value for it now?

Mr. IRISH. That is worth to-day $150 an acre—a fair market value for it.

Senator JONES. Do you think it would sell for that?

Mr. IRISH. Yes.

Senator JONES. It would cost $15 an acre to put water on it, and it would sell for $150 an acre?

Mr. IRISH. Yes.

The CHAIRMAN. What would make it $150 an acre?

Mr. IRISH. Its productive quality.

Senator JONES. Is that land off from the railroads?

Mr. IRISH. Yes.

Senator JONES. Is not that a fanciful price for the land?

Mr. IRISH. No.

The CHAIRMAN. Explain how it would be worth that much.

Mr. IRISH. The land will produce in a fair average season six and eight tons of alfalfa hay to the acre. That is worth in that region $15 per ton.

The CHAIRMAN. To feed stock?

Mr. IRISH. Yes.

The CHAIRMAN. How does it happen to be worth that?

Mr. IRISH. Its feed value makes it worth that? Alfalfa hay is as rich a feed as corn is in the Mississippi valley. It answers all the purposes of corn. It is not simply hay; it is a fat-producing food. Gentlemen who have had experience in feeding alfalfa hay to stock and animals say that it will fatten as well as corn.

The CHAIRMAN. And being surrounded by a region of country where there is abundance of summer food it helps to keep your stock. Is that the idea?

Mr. IRISH. Yes. I will describe the locality, and you can draw your own conclusion:

The Squaw Valley is surrounded by a range of mountains, varying in form, and the outlet of the waters from that valley is a narrow cañon on the south side, which was cut within recent years. That drains the valley and makes it dry land. The mountainous land surrounding that valley is rich and produces feed for summer stock. The people can put their stock on the mountains and fatten them in the summer, and in the winter they can feed them at the stalls with this alfalfa hay produced in the summer season. That makes its value; and I am satisfied to say that it is worth $150 an acre.

Senator JONES. Alfalfa hay is worth more there than it is here?

Mr. IRISH. Yes. It sold last year all over the country at $20 a ton.

Senator JONES. Is that the demand for it?

Mr. IRISH. Yes.

Senator JONES. Is the demand unlimited there?

Mr. IRISH. Yes. It is unlimited all over this country.

The CHAIRMAN. I think I know that there is an unlimited amount of feed in summer for the cattle, and that it costs very little to raise cattle in summer if you can feed and take care of them in winter. Would the statement that you have made with regard to the particular land you have in mind be true of all the land that could be brought under cultivation through that portion of the State?

Mr. IRISH. It would be true for that portion and all portions of the State. It will be a long time before the farmers of the country will catch up with the demand for feed.

The CHAIRMAN. I wish to ask you this question: What opportunities are there in this State for settlers, if they knew the facts, to go and make homes by such combination as they can make among themselves without accumulated capital?

Mr. IRISH. The opportunities are very good. If I had the time I could take a map and point out a great many localities in this State where aggregated settlements of thousands could be made, and every acre of land obtained and brought under cultivation could be made to produce as I have described; and being made to produce, would be equally valuable per acre with the land of which I have been speaking.

The CHAIRMAN. Of what value would surveys be in pointing out these places where water could be stored, and what amount of land could be irrigated if they were mapped and pointed out?

Mr. IRISH. It would be of the greatest value, because the people residing outside of the country generally look upon it as a barren waste, whereas it is not a barren waste. The only way in which they can be reached is by something official, which would be considered reliable.

The CHAIRMAN. In your official capacity you have traveled extensively over the State, and have given particular attention to this subject?

Mr. IRISH. Yes.

The CHAIRMAN. Have you made any report calling attention to these matters that would be useful?

Mr. IRISH. I have. I have made two reports to the Commissioner of the General Land Office in regard to these matters, and in the reports have given reliable information gathered from reliable persons, men who are thoroughly located and have been located for a number of years in various portions of the State. I gathered from them the results of their labors.

The CHAIRMAN. Have those reports been printed?

Mr. IRISH. I have just sent one off to Washington.

The CHAIRMAN. Could you, for the use of the committee, furnish another report?

Mr. IRISH. That is my intention. I have one partly prepared. Official duties prevented me getting it completed for this occasion.

The CHAIRMAN. We want in that report attention directed to the opportunities of settlers, not for capitalists, with a general idea of how many dollars per acre it would take, showing the chances for market, etc. And you might have it accompanied by a map with a short explanation.

Mr. IRISH. I intended to make it embrace something about the amount of water that could be stored every season, with the average amount of evaporation, so that some estimate could be made of the amount of land that could be irrigated.

STATEMENT OF TRENMORE COFFIN, OF ORMSBY COUNTY.

Mr. Chairman and gentlemen, I have no detailed report for the reason that I thought you would have a sufficient amount of detail. I have been appointed by the county commissioners of this county to appear before you, and all I wish to say is a word about what the people want. I have talked with the people of this State, and they wish information as to how they shall improve the opportunities which they have.

It is a well known fact that there are many millions of acres of land in this State that need irrigation, and that a great deal of water goes to waste. But how to get the land and water together the people do not understand.

I am engaged with some of my neighbors and friends in constructing an irrigating canal, but the difficulty we find in our way is the absence of practical knowledge of how irrigating canals can be built, where reservoirs can be established, and what precautions are necessary to be taken to prevent disaster in times of flood. If the people had more information that is definite and reliable to depend on a great deal more could be done.

Senator REAGAN. We are not engineers, and can not give you information on that head. We are seeking information.

Mr. COFFIN. If the Government could say how and where reservoirs could be built, that information would be valuable. It is considered by all parties that 90 per cent. of the water of this State goes to waste, and from an agricultural stand-point the value is in the water. There is no question about the land and the water, but the safe means of getting the two together is what we need information about.

Senator JONES. Then if the Government were to examine the country and point out the reservoir sites, with other information of that sort, you think it would about solve the difficulty with which you have to deal?

Mr. COFFIN. It would solve the beginning of it. I think in this State the limit is reached where an individual, a poor man, can go out and find a home, as in Illinois, Indiana, and Ohio—where he can go individually and alone and take out water to irrigate his land. But there are thousands of places where a small colony could go together, and by a combination of their forces and means construct a canal and make homes for themselves. But it is beyond the reach of the individual, of the poor men. If the information were given showing where a colony could go and expend their means in this way, a great deal of land could be brought into use which is now going to waste. It is no use now to the Government, to the State, or to individuals.

The committee took a recess until 3 o'clock.

The committee re-assembled at 3 o'clock p. m.

STATEMENT OF WILLIAM THOMPSON, OF RENO.

The CHAIRMAN. What can you tell us in regard to irrigation in Nevada?

Mr. THOMPSON. I wish first to present the report of the special committee appointed by the State Board of Trade of California, which was prepared for your committee, and which is quite extensive, and which gives a very interesting account of irrigation on this coast.

[The report will be found in the record of the committee's proceedings in California.]

The CHAIRMAN. That relates to California mostly, I suppose?

Mr. THOMPSON. Principally to California, but it also relates to Nevada. It shows the amount of land that can be reclaimed, and gives a very full and complete account of the lands, the climate, and so forth. I wish to present it to you because it interests this part of our State very much.

The CHAIRMAN. Have you been interested in the subject of irrigation?

Mr. THOMPSON. I have been interested in the subject of irrigation in this State for about thirty years. I have owned land in this section of the country for that period of time.

The CHAIRMAN. What success have you had with land when you have employed water for irrigation?

Mr. THOMPSON. The finest kind of success. I never made a failure of a crop where I had water, nor did my neighbors ever make a failure of a crop where they had water.

The CHAIRMAN. What is an average crop of wheat in this State, where you have water to irrigate it?

Mr. THOMPSON. About 20 bushels, but it is sometimes as low as 10 or 15; sometimes it will go as high as 30, 40, or 50 bushels to the acre, depending on the soil and locality. The average might be called 20 bushels to the acre. It will average more than California.

The CHAIRMAN. Will not irrigated land average more than 20 bushels?

Mr. THOMPSON. In certain localities, certainly it will. But the average will not go, I think, over 20 bushels. We do not raise a very extensive crop of wheat in this section. In some sections it is good and some not very good. In some parts they raise 15 bushels, and in other parts 40 and 50 bushels to the acre. But I think from 20 to 25 bushels *would be a very* fair average. The wheat is of the very best quality.

We got the first premium in the United States for the best wheat produced in the country.

The CHAIRMAN. How much barley?

Mr. THOMPSON. Our people have in a great measure quit raising barley, on account of the teaming interest having been all done away with. They raised fair crops of barley—more than of wheat. It will do with less water.

The CHAIRMAN. How is it as to the crop of potatoes?

Mr. THOMPSON. The finest potatoes that are raised on the coast are raised in Nevada.

The CHAIRMAN. How much do they yield?

Mr. THOMPSON. From 5 to 10 tons to the acre.

The CHAIRMAN. How many bushels?

Mr. THOMPSON. I can not estimate it by bushels; we estimate such things here by tons.

The CHAIRMAN. Have you attempted to ascertain the amount of land that could be reclaimed in Washoe County if water could be had?

Mr. THOMPSON. Yes.

The CHAIRMAN. How much is there that can be reclaimed?

Mr. THOMPSON. In one valley north of Reno, in that section of country, there is probably 50,000 acres that could be reclaimed. That amount could be increased to a considerable extent—it could be continued up to probably 100,000 acres on the north side of the river.

The CHAIRMAN. What is land worth about Reno, that is, land under cultivation?

Mr. THOMPSON. It averages about $100 an acre.

The CHAIRMAN. Does it pay interest on that amount?

Mr. THOMPSON. Yes; it pays 10 per cent. on that amount, by good management. I wish to say that we are all deeply interested in the question of irrigation, but we have met with this difficulty: All the sources of water supply are in the State of California, and when you come to investigate it you will find they are owned by private parties.

The CHAIRMAN. How are they owned?

Mr. THOMPSON. Parties have Government titles and patents, and they claim to own the land. It is therefore difficult to do anything with it.

The CHAIRMAN. Has anybody a Government patent to Lake Tahoe?

Mr. THOMPSON. They have a patent for the outlet.

The CHAIRMAN. At any rate not more than one-third or one-half of your water-shed comes from Tahoe.

Mr. THOMPSON. But the other lakes are in the same fix.

The CHAIRMAN. I do not think the lakes belong to individuals. The Government owns the lakes.

Mr. THOMPSON. But the Government does not intend to build reservoirs.

The CHAIRMAN. The Government owns the lakes and is going to reserve them for the people. The Government has not sold the lakes, and nobody can get any title to the lakes. The Government has already reserved the right of way to construct ditches, and if any man has got in the way of the right of way, we will have to condemn the right.

Mr. THOMPSON. Our people would willingly raise funds to construct reservoirs and ditches if we could get rid of the difficulty I spoke of.

The CHAIRMAN. There is no difficulty. There is no necessity for considering Lake Tahoe indispensable; you have plenty of water without it. I believe you have many times as much water as you now use, without Lake Tahoe.

Mr. THOMPSON. A great deal of water undoubtedly goes to waste from the Truckee.

The CHAIRMAN. At least three-fourths of that comes from sources other than Lake Tahoe.

STATEMENT OF GEORGE NICHOLL, OF BELMONT.

The CHAIRMAN. How long have you resided in Nye County?

Mr. NICHOLL. Since 1871.

The CHAIRMAN. What is your occupation?

Mr. NICHOLL. I am a prospector, assayer, millman, and miner.

The CHAIRMAN. Have you given any attention to irrigation?

Mr. NICHOLL. Considerable.

The CHAIRMAN. Have you any report from Nye County on that subject?

Mr. NICHOLL. I have a short report.

The CHAIRMAN. Who made it?

Mr. NICHOLL. I did.

The CHAIRMAN. What does it relate to?

Mr. NICHOLL. It relates to the arid lands of Nevada and the means of supplying water for irrigation.

The CHAIRMAN. Are all your views contained in that report?

Mr. NICHOLL. Not all.

To the honorable Senate Committee on Irrigation:

By resolution of the board of county commissioners of Nye County, a certified copy of which is herewith presented, the undersigned was appointed to collect such facts and data in relation to the water supply and make suggestions as to how it might be increased; also to make an approximation of the amount of arid land which could be rendered suitable for agricultural purposes within Nye County, and report the result to your honorable committee.

In performing the duties expected of me I will endeavor to be as brief as possible, being well aware of the additional labor imposed upon your honorable committee and the brief space of time allotted you for the purpose of investigating this important subject.

No other question of the day is attracting so much attention in our county as the water question. The long-continued drought, extending back for several seasons, has rendered it necessary that some action should be taken, both for the agricultural and stock interests, each of which is suffering and feels the need of an additional supply of water at the present time.

It is universally acknowledged to be a wise step taken by the Government in making appropriations for the purpose of reclaiming the arid lands in these western States and Territories—a step which may, and no doubt will, repay it many hundred fold in the near future by opening up to settlement tracts of rich lands now practically uninhabitable for want of the knowledge and means of utilizing the waters annually running to waste. It shows the wise forethought of this great Government in providing for the future of its people by making it possible for them to acquire cheap homes in a fertile and healthy climate, where by industry they may secure wealth, independence, and comfortable homes.

I find it to be nearly the unanimous wish of all the citizens of this county that the hydrographic surveys, now in progress in the western portion of our State, be extended into Nye County at an early date. Certainly no portion of the United States needs the benefit that may be derived from its operations more than this.

It is not only my opinion, but the opinion of substantial citizens who have given the subject close and earnest consideration, that it will be the best investment for the future prosperity of the nation that it can enter into, not only to continue the surveys, but to increase the Government appropriations for the purpose of aiding in the construction of the necessary work and in the development of the country for artesian water where small quantities of extra rich land are situated and it is found impossible to obtain a supply of water from other resources.

Such works as are required are often too expensive for any single individual or a small body of men to undertake, and should be a national undertaking. If a constant *and sufficient* supply of water could be obtained by any means it would create a *demand for the* unsettled lands at better prices than can be obtained at present, create

taxable property, and encourage the immigration and settlement of a healthy and industrious class of citizens, which would soon increase both the wealth of State and nation, and this at present desert land would in a few years become the garden of the United States.

The resources of Nye County are scarcely known or heard of outside of its own boundaries. It is generally supposed to be a great barren desert, composed of sand and sage-brush, of little account except for grazing purposes, with a few low-grade silver mines and a limited supply of arable land.

It may be a surprise to some of your honorable committee to find a different state of things presented for your consideration. The county has an area of about 12,500,000 acres. Of this vast territory I am fully convinced that over 6,000,000 acres are capable of a high state of cultivation. Some good judges place it at about 8,000,000, of which less than 800,000 is under cultivation or under fence for grazing purposes.

Where sufficient water can be obtained for irrigation I find the following cereals and vegetables grown to perfection, viz: Of cereals and grasses, wheat, barley, oats, corn, rye, beans, peas, buckwheat, timothy, red-top, blue-joint, clover, alfalfa, millet, wild oats, wheat, and rye, and bunch grass of several varieties; of vegetables, potatoes, cabbage, onions, turnips, tomatoes, rutabagas, carrots, parsnips, pea-nuts, radishes, beets, melons, squash, horse-radish, cresses, etc.

The hops and sugar-beet will, I think, be a source of great revenue in the near future, as they yield immensely and both take to the soil like natives.

Of the wild native grasses and forage plants there are a great variety, chief among which are the sand bunch grasses, white sage and wild clover of the valleys, and the bunch grasses and mountain or burr clover of our mountains and hill-sides.

Of fruits we cultivate the apple of many varieties, pears, apricots, nectarines, plums, cherries, grapes, nuts of several kinds, and many of the small fruits and berries. This industry is in its infancy yet, but it has been successful, so far, beyond our greatest expectations.

Of timber and wood we have the yellow, black, and white pine, and fir in limited quantities, an abundance of nut-pine, juniper, cedar, mountain mahogany, cotton-wood, balm of Gilead, quaking-asp, willows, etc.

Of shrubs, the mountain aloes, sage-brush, and greasewood of many varieties, rabbit-bush, Spanish broom, etc.

Of wild fruits we have but few—wild currants, gooseberries, cherries, buffalo berries, cactus, etc.

For the variety and abundance of its mineral deposits it is not excelled by any county in the State. We find gold, silver, copper, lead, zinc, antimony, cinnabar, and other metals; building stone in great variety, granites, porphyry, slates, limestone, gypsum, hydraulic cement, fire-clay, chalk, soapstone, borax, soda, salt, alum, etc., and excellent material for both fire and building brick, etc.

Wood for fuel, mining, and fencing purposes is in abundance. Our great needs are a sufficient supply of water for agricultural purposes, the return of silver to its original standard of value, and railroad communication with the outside world, so that we can obtain our needed supplies at reasonable rates and find egress to markets for what we produce.

By careful inquiry, I find the following to be the yield per acre where sufficient water can be obtained for irrigation, viz: Wheat, barley, and oats produce from 1,200 to 3,000 pounds per acre; timothy, about 1 ton; alfalfa, two or three crops per season, with a yield of 3½ to 5 tons per acre. Of the other products of the soil, such as vegetables, fruits, etc., no definite amount can be fixed upon, as no account is kept. Such products are used up for home uses, or sold in small quantities as they mature. Without water the yield is too small to be taken into account, except in rarely wet seasons.

The situation of Nye County as regards water is peculiar differing from nearly every county in the State, as it has neither lakes, rivers, nor large streams from which to draw a supply for irrigating purposes, and it is entirely dependent upon the snow-fall in the winter and the rains, when we have any, through the summer, and the large natural springs found near the bases of the mountain ranges and in the valleys for its supply, which is barely sufficient to irrigate the acreage under cultivation in favorable seasons and for stock and domestic purposes, owing to the great loss while the snow is melting in the mountains in the spring, and summer rains. This loss I estimate at fully eight-tenths of the whole.

Under present circumstances it is impossible to arrive at anything like a correct estimate of the yearly amount of water used for irrigating purposes or the amount wasted. It would require a person equipped with the proper instruments to be on the ground and make an examination every month, from March to August, to get at it in any reliable form. I had only a little over a month, and that when the waters are nearly at their lowest state, and I find that no regular system of irrigation or measurement has yet been adopted by the farmer. Their ditches are all made in the way "the Missourian made *the plow*," and are calculated to carry what water they

can get, regardless of waste. Not one of them that I have met can estimate the number of inches, miner's measurement, their ditches will carry, or the amount furnished by streams used by them. Few of the ditches have been surveyed, or have any regular grade, and only in three or four instances does the same ditch supply more than one farm, so that getting the data you require is not only difficult, but impossible, during the time at my command and the extent of territory embraced within the county lines.

I would suggest that Colonel Bridges, who has charge of the work, send a competent person, upon whose judgment he can depend, to Belmont next April or May, to make an investigation of the waters used and also running to waste at that season, also to examine the facilities for storage reservoirs, etc. I will willingly spend a few weeks in showing him what I have myself observed, and give him an opportunity to converse with all the prominent ranchers in the county.

It will be seen by the county map that it has numerous cañons which afford streams—estimated from my familiarity with mining ditches in California—varying from 50 to over 2,000 inches of water for a short period, and springs varying from a few inches to 800 inches, with numerous excellent sites for storage reservoirs in the mountain parts, cañons, foot-hills, and valleys.

The importance of impounding and storing these waters for irrigating purposes in these arid sections is so well understood at the present day that argument or comment is unnecessary. But in connection with these works I have a few suggestions to add, which, I think, if carried out, would add materially to the water supply.

I have noticed that only those cañons and ravines whose sides are lined with trees and underbrush furnish any considerable amount of water. The trees and shrubs form a lodgment and shelter for the snow, allowing it to accumulate, and protecting it from the fierce rays of the sun and hot winds, and the decayed vegetation forms a soil which holds and gradually conveys the moisture from the melting snow on the hill-side downward to the beds of the cañon.

If the planting of the seeds of such trees and shrubs as would grow on the hill-sides was encouraged, a great additional supply of water might be obtained in time.

If the water branches and springs, which are found near the base of all the mountains, were properly opened and kept free, it would add to the supply; as the cattle in search of water tramp the soil in the vicinity of these springs into a thick mud, which prevents a natural flow. These should be opened and piped into strong tanks, where cattle can drink the water conveniently. It would afford an ample supply for stock which is now suffering, as the flow of the springs is thus obstructed.

If the large springs in the valleys and foot-hills—I call them natural artesian wells—were opened by means of pipes driven through the mud and sand, and cleaned out by means of sand-pumps or jetting apparatus, it would increase the flow, and in many places furnish a good supply not otherwise obtainable.

Small reservoirs could be built at little expense. Many of these are now in use in our country, some of them containing less than 10,000,000 cubic feet of water, but which are of very great benefit.

If the large streams which issue from the cañons in the spring (and which could not be impounded to advantage) could be carried over the heavy beds of loose gravel deposited by the spring floods, and usually extending a mile or two below the mouth of the cañons, to soil capable of conveying the water in ditches without much loss it would be of immense benefit to the farmers, as many heavy streams are lost in these deposits in flowing less than a mile.

I have suggested piping and fluming, but both are too expensive where only one or two ranches can be benefited and the freight on pipes and lumber generally exceeds the first cost of the material.

I have also suggested the use of canvas hose, which could be stretched upon the ground and taken up after the irrigating season is over. Also the use of thin sheet or galvanized iron, on which the freight would also be light as compared with pipes or lumber. The sheets would come in bundles and could be shaped on the ground, into either square or V shaped troughs, and where the fall is great—usually over 300 feet to the mile—would carry a large amount of water. The boxes could be made to fit into each other an inch or two, and the grade would prevent leakage at the joints; only slight excavations would be necessary to hold them in place, and they could be taken up and stored when not in use. These boxes would not be damaged by heat and exposure, like lumber or canvas, and the expense of deep trenches and covering would be avoided.

Another source of supply I am satisfied can be obtained from artesian deposits. Much of the rains and heavy snows deposited on the mountains never reach the valleys, but are absorbed and disappear in the crevices of the bare rocks, especially where they are much tilted. These act like a sponge and as feeders to the water deposits below.

The central and southern portions of the county should be well tested for these *artesian basins*, as much of the best arable land lies in this vicinity, and no attempt

has been made at cultivating this portion of the soil, for the want of water, from a short distance south of Belmont until you reach Ash Meadows and Pahrimp Valley, near the extreme southern portion of the county.

I have no doubt also that underground streams exist to a great extent, which might be utilized, as fish of the chub species varying from 1 to 6 inches in length are found in many of the large springs. In some of the warm springs these fish are numerous. The question is where do they come from? We have neither surface streams nor lakes in which fish are found, unless transplanted from abroad.

Near Twin Springs, in this county, are several large water holes which abound in these fish. These holes have been sounded to the depth of several hundred feet, but no bottom has been found. If, in the early morning sunrise, you gaze steadily into the clear water, you will see the bottom of the crust of earth which overlies these waters. The valley evidently has an underground lake, and these springs are either where the force of the water has worked its way to the surface, or the crust has from some cause broken in and disappeared in the depths below. There are many of these water holes in the county, which may be utilized in the future.

In the Hot Creek Range, near Tybo, is a butte, where, by placing the ear to the crevices in the rock, the rushing sound of water may be distinctly heard.

In Cave Valley, formerly in Nye County, but now in White Pine, I am informed there is a cave which in the spring of each year regularly discharges a large amount of water for about six weeks, then it suddenly ceases. There are many other evidences of underground waters in this county.

The main reason why so little interest has been taken in developing the water supply in this county arises from the fact that all the products of the farm are dependent on the home market, and the supply of all farm produce is in excess of the demand of late years. I wish to call your honorable committee's attention to this fact, that since the demonetization of silver and the heavy reduction in its price nearly every industry in the county has fallen off. While silver was at or near its par value the mining towns afforded a market at good prices for all the farm products that could be raised; but under the present discount of silver mine after mine, mill after mill, and all the furnaces in the county have been obliged to close down, with the exception of one small concentrator of a capacity of about 30 tons per day. Mining towns and camps containing populations of from 1,000 to 2,000 have been deserted, or nearly so. For example, unground barley, which formerly found a ready market on the ranches at 5 cents per pound, and retailed at from 6 to 8 cents per pound, is now retailed, ground, at from 1¼ to 2½ cents, and other farm products in proportion, with little demand for anything at present.

Not having a mile of railroad within our county by which we might find an outlet for our products, you will perceive that the business of farming, as well as mining, is handicapped. In fact there is no encouragement for enterprise as formerly. How long this state of affairs is to continue remains with you and your colleagues in Congress to say.

With mines enough to furnish work for thousands of miners at remunerative wages, unsettled land enough to furnish homes for thousands of industrious families, who would also add to the wealth and prosperity of the nation, but only a few scattering settlers exist, and those only by turning their attention to stock raising to eke out an existence. Soil as deep and rich as can be found in any portion of the Union, grasses and forage plants, succulent and nutritious, grow on hill and valley.

There are other precious metals and other minerals in every mountain and valley, with numerous excellent sites for storing water in the mountain parks, cañons, foothills, and valleys.

We await but recognition on the part of the General Government to place Nevada among the foremost in the galaxy of States.

GEO. NICHOLL,
Commissioner on Irrigation from Nye County, Nevada.

The CHAIRMAN. You estimate that there are 6,000,000 acres of arable land in Nye County?

Mr. NICHOLL. Yes.

The CHAIRMAN. How much of that 6,000,000 acres could be irrigated?

Mr. NICHOLL. Probably a little more than half of it could be irrigated—3,000,000 acres.

The CHAIRMAN. In addition to what you have there already?

Mr. NICHOLL. Yes.

The CHAIRMAN. If from surveys and maps the facts were known with regard to the arable land, the sources of water supply, and such other information as might be necessary to enable settlers in advance to un-

derstand what they could do, would it be possible for settlers to combine and do anything with that country?

Mr. NICHOLL. I think it would be. We are very anxious now to have some one go there and examine the country for the purpose of locating reservoirs—anxious to have Mr. Bridges go there and obtain some information for us. Indeed, I am the only one in the county who has tried to force anything through. The people there are very much discouraged by the home market, and about the situation at the present time on account of silver—it is a mining country altogether—and they are finding no market for their produce.

The CHAIRMAN. Have anything else you wish to say?

Mr. NICHOLL. I have a report on the state of the weather in that section which I would like to have incorporated.

The CHAIRMAN. Very well, it may be inserted in the record.

The report is as follows:

Nevada State weather service.

[Daily report of observations for the month of July, 1889. Place of observation, Belmont, county of Nye, State of Nevada. Latitude, 38° 33′; longitude, 116° 45′. Height of ground above sea-level, 8,100 feet.]

Day of month.	Hour of observation.	Temperature.			Wind, prevailing direction.	State of weather.	Remarks.
		Maximum.	Minimum.	Range of.			
1	7 a. m...	86	56	30	Southerly and varying..	Clear	Light breezes.
2	...do	86	51	35	.....do	....do	Do.
3	...do	89	57	32	.....do	....do	Do.
4	...do	90	64	36	.....do	....do	Do.
5	...do	95	62	33	.....do	....do	Do.
6	...do	96	64	32	.....do	....do	Distant thunder.
7	...do	95	61	34	.....do	....do	
8	...do	89	55	34	.....do	....do	
9	...do	81	58	23	.....do	Clear and cloudy p.m.	
10	...do	78	56	23	.....do	Clear.....	Strong breezes.
11	...do	80	57	23	.....do	....do	
12	...do	82	58	24	.....do	....do	
13	...do	86	67	19	.....do	....do	
14	...do	83	64	19	.....do	....do	
15	...do	85	54	31	.....do	....do	
16	...do	80	57	23	.....do	....do	
17	...do	77	54	23	.....do	....do	Light breezes.
18	...do	79	55	24	.....do	....do	Do.
19	...do	80	56	24	.....do	....do	Do.
20	...do	86	60	26	.....do	...do	Do.
21	...do	88	61	27	.....do	Cloudy.....	Do.
22	...do	81	60	21	.....do	Clear	Do.
23	...do	85	63	22	.....do	....do	Do.
24	...do	86	59	27	.....do	....do	Do.
25	...do	87	55	32	.....do	....do	Do.
26	...do	88	61	27	.....do	....do	Do.
27	...do	87	55	32	.....do	... do	Do.
28	...do	86	56	30	.....do	....do	Do.
29	...do	82	56	26	.....do	....do	Do.
30	...do	94	73	21	..... do	... do	Do.
31	...do	93	74	19	.....do	....do	Do.

JOHN REYNOLDS,
State Weather Observer.

The CHAIRMAN. What is the average rain-fall?

Mr. NICHOLL. It comes at various times. Sometimes we will have a large amount—a flood. I have seen the streets of Belmont that high *with water [indicating a foot].*

STATEMENT OF JAMES MAYBERRY, MEMBER OF THE STATE BOARD OF COMMISSIONERS.

The CHAIRMAN. Have you given much attention to the subject of irrigation in the district in which Washoe is situated?

Mr. MAYBERRY. I have given it some attention.

The CHAIRMAN. Can you add anything to the information we have already obtained on the subject? What have you to say about it?

Mr. MAYBERRY. I do not know that I could add to what has already been said.

The CHAIRMAN. Give us the result of your observations; what you have seen there, and what can be done.

Mr. MAYBERRY. The situation there now is this: There is hardly enough water flowing in the river to irrigate the land which is now under cultivation.

The CHAIRMAN. What is under the water-shed? Is there enough under the water-shed if it were saved?

Mr. MAYBERRY. Yes, and to irrigate more land than they have in the county.

The CHAIRMAN. More than can be reached from the Truckee River?

Mr. MAYBERRY. Yes.

The CHAIRMAN. How much land could be reached from the Truckee?

Mr. MAYBERRY. Probably 150,000 acres on the north side.

The CHAIRMAN. In addition to that under cultivation?

Mr. MAYBERRY. In addition to that.

The CHAIRMAN. Is that all—150,000 acres?

Mr. MAYBERRY. Probably there could be more than that at a greater expense——

The CHAIRMAN. How much an acre would it cost to irrigate the 150,000 acres—to bring the water so that the parties there could use it?

Mr. MAYBERRY. If the sites for reservoirs, ditches, etc., were free, I think that $10 or $12 an acre would do it.

The CHAIRMAN. What would the land be worth when that was done?

Mr. MAYBERRY. Anywhere from $40 to $60 an acre.

The CHAIRMAN. It would be as valuable as that already irrigated?

Mr. MAYBERRY. That land is more valuable.

The CHAIRMAN. And the unirrigated is better land?

Mr. MAYBERRY. Better land—that is to say, deeper soil, and would take less water to irrigate it.

The CHAIRMAN. Have you examined the storage basins in these rivers above?

Mr. MAYBERRY. Yes. I have examined around those lakes and natural meadows and outlets to them, and there are chances to put in storage dams.

The CHAIRMAN. Are the opportunities abundant?

Mr. MAYBERRY. Yes, more than abundant.

The CHAIRMAN. Some of the land is public land?

Mr. MAYBERRY. I do not know about that. It seems to me that most of the land is taken.

The CHAIRMAN. Then the land would have to be condemned?

Mr. MAYBERRY. It would have to be condemned and bought.

The CHAIRMAN. The land is all surveyed.

Mr. MAYBERRY. Yes, and as well as I can get at it it is owned by individuals.

The CHAIRMAN. Except the lakes.

Mr. MAYBERRY. Except the lakes. The margins of the lakes are owned. In some of them you would have to raise water, and if you raised it 15 or 20 feet you would overflow some meadows or pasturage land used by stockmen in summer.

The CHAIRMAN. Have you anything else to say about this matter that would be of value to the committee?

Mr. MAYBERRY. No, nothing further than to say that if the people had the right to go to work and put dams at these outlets they would do it themselves. But they have no right to shut up those streams, because somebody else would require them to be opened.

STATEMENT OF GEORGE S. HAWKINS, OF CARSON CITY.

The CHAIRMAN. Have you been engaged in the business of boring artesian wells in Nevada?

Mr. HAWKINS. Yes.

The CHAIRMAN. Make a statement of the wells you have sunk, and state with what success you have met.

Mr. HAWKINS. I have bored about 5,000 feet of wells, varying from 40 to 400 feet in depth.

The CHAIRMAN. In what section of the State?

Mr. HAWKINS. Most of them in this county. I bored one well in Churchill County and one in Douglas County.

The CHAIRMAN. About how many have you sunk in Ormsby County?

Mr. HAWKINS. About thirty.

The CHAIRMAN. About how many are flowing wells?

Mr. HAWKINS. About two-thirds.

The CHAIRMAN. What is the average depth?

Mr. HAWKINS. The artesian water comes within 120 feet. That is to say, that which is of any consequence.

The CHAIRMAN. What sized wells are they?

Mr. HAWKINS. Three inches.

The CHAIRMAN. How much water do they flow?

Mr. HAWKINS. The best of them struck in this county flow about 30 gallons a minute, and the others, as the formation is finer, flow less; some of them only two or three gallons a minute.

The CHAIRMAN. What are the formations through which the drill passed?

Mr. HAWKINS. Alternate strata of sand and clay down to the bottom of the artesian belt, and that becomes a finer formation, such as you would find in the bottom of lakes—sedimentary.

The CHAIRMAN. There is sand where you get the water?

Mr. HAWKINS. Yes.

The CHAIRMAN. And above that is clay?

Mr. HAWKINS. The sand is between two beds of clay, which are impervious to water.

The CHAIRMAN. You sunk a well in Churchill County?

Mr. HAWKINS. Yes; for the Vail Brothers.

The CHAIRMAN. Near the Carson River?

Mr. HAWKINS. Right on the Carson River.

The CHAIRMAN. How far above or below Carson?

Mr. HAWKINS. East of Carson City.

The CHAIRMAN. How far down the river?

Mr. HAWKINS. Between 40 and 50 miles.

The CHAIRMAN. To what depth did you sink that well?

Mr. HAWKINS. To a depth of 400 feet.

The CHAIRMAN. Did you strike water?

Mr. HAWKINS. I struck pump water; no water that came to the surface.

The CHAIRMAN. What formations did you pass through?

Mr. HAWKINS. Beds of quicksand; very few beds of clay. The majority was quicksand, which I imagined had been carried through from here down into the sink.

The CHAIRMAN. At the bottom of the well what did you find?

Mr. HAWKINS. Sand. I struck a belt of clay 12 feet thick, and between that and the sand, the top stratum was yellow clay and the bottom blue.

The CHAIRMAN. Did you go below the bed of clay?

Mr. HAWKINS. Yes.

The CHAIRMAN. What did you find?

Mr. HAWKINS. Quicksand.

The CHAIRMAN. Did you go through that?

Mr. HAWKINS. No; the parties for whom I was sinking the well did not care to go deeper and I stopped there. I think if they had struck nearer the river they would have gotten artesian water.

The CHAIRMAN. It is not prospected there?

Mr. HAWKINS. No.

The CHAIRMAN. Are there any wells sunk down on the bed of the Carson?

Mr. HAWKINS. Yes; one at the lower end of the valley, where a flow was gotten at a depth of 300 feet. It was a light flow.

The CHAIRMAN. Do you know through what formation they passed?

Mr. HAWKINS. The same formation, I understand, that I passed through.

The CHAIRMAN. They did not get down through the quicksand?

Mr. HAWKINS. No. This water is found in fine sand.

The CHAIRMAN. You do not know what may be below?

Mr. HAWKINS. That region has not been prospected.

The CHAIRMAN. There is no region that is prospected, I mean near the Sierra Nevada Mountains, in Carson Valley.

Mr. HAWKINS. In Douglass County I sunk two wells, and each of them flows 30 gallons a minute.

The CHAIRMAN. To what depth did you go?

Mr. HAWKINS. Three hundred and seven feet is one, and 310 feet is the other.

The CHAIRMAN. Through what formations did you pass?

Mr. HAWKINS. I struck sand and bowlders. I struck three strata of bowlders that were about 20 feet thick in one well, and in the other I struck two.

The CHAIRMAN. Clay bowlders?

Mr. HAWKINS. Sand bowlders.

The CHAIRMAN. No seams of clay in the bowlders?

Mr. HAWKINS. No. But above there was.

The CHAIRMAN. What was immediately above the flowing water?

Mr. HAWKINS. There was in the Rosser well—the lower well—a kind of hard pan and blue sand that was partially cemented together, so that after the well was struck portions of it as large as my fist would come up through the pipe.

The CHAIRMAN. That was impervious to water?

Mr. HAWKINS. Yes.

The CHAIRMAN. What did you find below that?

Mr. HAWKINS. There I stopped in blue sand.

The CHAIRMAN. There you got the water?

Mr. HAWKINS. Yes; I got the water. And I struck a granite sand in the other. That was deeper.

The CHAIRMAN. What did you have above the granite sand?

Mr. HAWKINS. A small streak of clay.

The CHAIRMAN. You think that is prospected?

Mr. HAWKINS. I think there is water there, and an abundance by going down deeper. The deeper you go the more water. At 90 feet the water came to within 6 inches of the surface; at 100 feet, 10 inches above the surface, and at 310 feet it flowed 6 feet above the surface.

The CHAIRMAN. Is that all the prospecting you did for water in western Nevada?

Mr. HAWKINS. Yes. There have been other wells sunk which they did not make a success of, and there have been wells sunk in Washoe Valley that struck pretty fair flows.

STATEMENT OF SILAS E. BURBANK, OF SMITH'S VALLEY.

The CHAIRMAN. In what part of Lyon County do you reside?

Mr. BURBANK. I am from Smith's Valley.

The CHAIRMAN. Have you any document prepared showing the condition of things in Lyon County?

Mr. BURBANK. Parties from Lyon were not in here, and there is no mail except twice a week, and they have not prepared to meet the committee at this time.

The CHAIRMAN. But they have made some preparation in that county to give the situation?

Mr. BURBANK. Yes.

The CHAIRMAN. How long have you resided in Lyon County?

Mr. BURBANK. For about twenty-five years.

The CHAIRMAN. Can you give any information about that county?

Mr. BURBANK. Yes; I can give you information about the amount of land that is under cultivation in that county.

The CHAIRMAN. How much land is under cultivation there?

Mr. BURBANK. The stream is pretty long, and there are two forks to it. We would have to start with the valleys at the head of it. There are a few small valleys about which I am not posted.

The CHAIRMAN. Give the amount of land in the aggregate.

Mr. BURBANK. There is in Lyon County somewhere about 30,000 acres of land cultivated by means of irrigation.

The CHAIRMAN. Do they cultivate all that can be brought under cultivation?

Mr. BURBANK. No; not more than about one-tenth.

The CHAIRMAN. Then you think they can get 300,000 acres under cultivation?

Mr. BURBANK. Yes. Eight years ago they had 125 miles of irrigating canals, some of them 12 feet wide, 4 feet deep, with about 6 feet fall to the mile.

The CHAIRMAN. Have they put that information in the report which they will send?

Mr. BURBANK. I presume they will do so.

Mr. IRISH. I wish to correct a statement made by me in the forenoon. *In speaking of* the area which I knew could be brought under cultiva-

tion in Lincoln County, I said it was 60,000 acres. I should have said sixty townships instead of 60,000 acres.

STATEMENT OF T. B. RICKEY, OF CARSON CITY.

The CHAIRMAN. In what business are you engaged?

Mr. RICKEY. I am engaged in the business of farming, ranching—raising stock.

The CHAIRMAN. Where are your ranches?

Mr. RICKEY. Principally on Walker River.

The CHAIRMAN. Where is that river?

Mr. RICKEY. It lies south and east of Carson City.

The CHAIRMAN. Part of it is in California and part in Nevada?

Mr. RICKEY. Yes.

The CHAIRMAN. Have you paid any attention to the subject of irrigation?

Mr. RICKEY. Some little; yes.

The CHAIRMAN. How much land have you reclaimed by irrigation?

Mr. RICKEY. I can not tell you exactly how much.

The CHAIRMAN. About how much; approximate it.

Mr. RICKEY. I should judge somewhere in the neighborhood of 15,000 actually reclaimed from a desert condition.

The CHAIRMAN. You have diverted upon this land the water of what river?

Mr. RICKEY. Walker River.

The CHAIRMAN. What use do you make of the reclaimed land?

Mr. RICKEY. It is principally used for raising stock.

The CHAIRMAN. What kind of grass do you raise there?

Mr. RICKEY. All kinds—redtop, timothy, alfalfa; in fact, all kinds.

The CHAIRMAN. About what is a fair crop of each kind of grass where the land is well cultivated?

Mr. RICKEY. I suppose what you mean is an average crop, where it has been well irrigated and well cultivated. I should say the timothy from a ton and a half to two tons an acre; probably a ton and three-quarters to the acre is an average crop.

The CHAIRMAN. How much of red clover?

Mr. RICKEY. English clover you would get two tons and a half.

The CHAIRMAN. Can you cut red clover more than once?

Mr. RICKEY. Yes; but your second crop of red clover in this country is not very heavy.

The CHAIRMAN. How much of alfalfa?

Mr. RICKEY. We calculate to cut an average of 4 tons to the acre.

The CHAIRMAN. In your place you cut only twice.

Mr. RICKEY. Yes.

The CHAIRMAN. What is about the altitude of your farm?

Mr. RICKEY. The altitude there is between 5,000 and 6,000 feet.

The CHAIRMAN. Lower down, where it is lower, you might cut more.

Mr. RICKEY. Oh, yes; we cut the third crop there, but we do not think it wise to do so.

The CHAIRMAN. Have you ever given the subject attention so that you would be able to state how much land there is below the flow of the Walker River and its tributaries that might be irrigated if there were water enough?

Mr. RICKEY. I have no means of making any estimate, except from observation.

The CHAIRMAN. That is all we expect.

Mr. RICKEY. I never thought anything about it.

The CHAIRMAN. You have passed over the country?

Mr. RICKEY. I should think that there are 150,000 acres of land that could be reached from the Walker River.

The CHAIRMAN. And much more?

Mr. RICKEY. Yes; that is a rough guess.

The CHAIRMAN. Is there any way of turning the Walker River over in the Carson valley in the Still Water Basin?

Mr. RICKEY. It could be brought over at Fort Churchill.

The CHAIRMAN. Have you been down in Churchill County to examine that country?

Mr. RICKEY. Yes.

The CHAIRMAN. Is there a large body of land there?

Mr. RICKEY. Yes, large tracts—a large country.

The CHAIRMAN. What is the character of the land?

Mr. RICKEY. It is large enough for a state.

The CHAIRMAN. Is it very fertile land?

Mr. RICKEY. Very.

The CHAIRMAN. And you could raise three crops of alfalfa there?

Mr. RICKEY. There would be no trouble in raising three crops of alfalfa in this country, and no trouble there—that is to put the water on the land at the proper time in the spring.

The CHAIRMAN. Are you familiar with the headwaters of the Walker and its various branches?

Mr. RICKEY. Yes.

The CHAIRMAN. Are these meadows and flats near the headwaters?

Mr. RICKEY. Yes.

The CHAIRMAN. What do you say as to the opportunities for storing water at the headwaters of the Walker River?

Mr. RICKEY. There would be no trouble at all. There can be water enough stored on the headwaters of the Walker and its branches to irrigate every acre of land that may be reached, and, I think, twice as much if all the water were stored. And there are facilities for doing it. has the best facilities that there are on this side of the mountains. There are facilities on the Carson, but they are better on the headwaters of the Walker than any I have seen. The water can be stored more cheaply there than at any other place.

The CHAIRMAN. Walker Lake is about 30 miles long and 10 miles wide, is it not?

Mr. RICKEY. It is about 15 miles in width, 12 or 15.

The CHAIRMAN. Is it a deep lake?

Mr. RICKEY. Yes, a very deep lake.

The CHAIRMAN. That lake is made from the surplus water of the Walker River, and it is all wasted?

Mr. RICKEY. Yes.

The CHAIRMAN. Then there is no difficulty in irrigating this Carson Sink if these waters were saved?

Mr. RICKEY. None at all.

The CHAIRMAN. To what extent have parties taken possession of the country that would be suitable for storage reservoirs?

Mr. RICKEY. To a very limited extent. That is my idea about it. I think plenty of places could be found for the storage of the waters of the Walker River. There are places though where the land has been *taken up*, but in a majority of the cases where the people own that land *they will vacate it*, because, as a rule, the land belongs to men who own

below, and they would be perfectly willing to have the water stored. There is fertile land enough on Walker River, in my opinion, to supply 300,000 of population. That land is right on Walker River. I am not making any wild statement; I have figured on this. On Virginia Creek, which is the extreme eastern branch of the Walker River, we have several lakes reservoired by constructing bulk-heads, and I have had water furnished me this season for 4,000 acres of land. Therefore, the entire expense of doing that would not reach over $3,000.

The CHAIRMAN. By means of those reservoirs you have irrigated how much land?

Mr. RICKEY. Four thousand acres of land which I could not have irrigated at all had it not been for those reservoirs. My idea is that the storage of water on the Carson is the most expensive of any of the streams. I am familiar with the headwaters of all those streams, and the storage of water is not so cheap there. At Twin Lakes, on one of the branches of Walker River, at what is called Robinson Creek, the people on Big Meadows thought they were going to have a scarcity of water. So they joined together and agreed to pay in accordance with the number of acres of land they owned. They dammed both of these lakes, and I was told when I was up there that it cost between $1,400 and $1,500, and the water is a little over 9 feet deep.

The CHAIRMAN. What is the size of the lake?

Mr. RICKEY. I think that the surface of the water would be a half mile by three. The grasses that we grow over here are so much more nutritious than in any other part of the world. Our grass here is equal to the corn grown in the East. I can take the grass here and fatten a steer, and put more actual meat on it in weight than they can with corn in the East.

STATEMENT OF D. C. WHEELER, OF RENO.

Mr. Chairman and gentlemen, I wish to tell you what we can do down on the Truckee Meadows, as shown by actual experiments. Around Reno we can put up any kind of stock, horses, cattle, or sheep that may be poor in the fall, and turn them out fat enough to kill in the spring. I have seen that done. We can put 2 gross pound of meat a day on a steer by putting it on alfalfa hay. The alfalfa here is worth more to fatten cattle than wheat, oats, or corn.

The CHAIRMAN. How is it for hogs?

Mr. WHEELER. It does well.

Mr. RICKEY. I have fattened a hog on alfalfa.

Mr. WHEELER. I think the hay for horses the best in the world.

The CHAIRMAN. Do horsemen use it?

Mr. WHEELER. On the Truckee meadows they use it altogether. We work the horses hard day in and day out without a bite of grain—give them nothing but alfalfa.

The CHAIRMAN. Do they use altalfa hay anywhere else except in Nevada?

Mr. WHEELER. It is shipped and used in California.

The CHAIRMAN. Do they not take it to New York?

Mr. WHEELER. Not alfalfa. They do take Nevada hay and timothy. I know parties shipping timothy hay for horses from here to New York.

The CHAIRMAN. How is it about the hay for feeding fine horses?

Mr. RICKEY. Horsemen consider the timothy produced in Nevada superior to any hay in the world. They have bought and shipped hay from here to New York for horses. Haggin did it.

Mr. WHEELER. We can put two gross pounds of meat a day on a steer by feeding it on alfalfa hay. We can put up stock after a five-hundred mile drive and have them fat in the spring without feeding them on grass at all, simply by feeding them on alfalfa hay. I have seen horses that were hide-bound really fat in three months after having been fed on alfalfa hay And alfalfa does not exhaust the vitality of the land. You can take a piece of land that has been ten or twenty years in alfalfa and then put it into grain and it will raise more than ever before.

The CHAIRMAN. How long will the alfalfa last?

Mr. WHEELER. In Truckee meadows it is 25 years old. It depends on the soil.

The CHAIRMAN. What is its condition now?

Mr. WHEELER. As good as it ever was.

The CHAIRMAN. Did you ever know it to diminish?

Mr. WHEELER. The yield generally diminishes as the plant gets old. It gets poor. You might injure the plant by not irrigating enough, and if the land be shallow the plant gets stunted.

The CHAIRMAN. What would you call an old plant?

Mr. WHEELER. It depends on the land. On some land down there with a foot of soil it gives out.

The CHAIRMAN. When?

Mr. WHEELER. In five or six years. Then we plow it up and reseed.

The CHAIRMAN. That renews it again?

Mr. WHEELER. Yes; it is then just as strong as ever. Two or three meadows down there have deep soil, and it is twenty-two and twenty-five years old, and it is as good as ever.

Mr. MAYBERRY. I have some that was put in in 1863, twenty-six years ago, and I have cut 3 tons to the acre the first cutting.

The CHAIRMAN. Is it good and fresh?

Mr. MAYBERRY. I think it is better and requires less irrigation.

Mr. WHEELER. I want to say that outside the land in Washoe County is 40 to 50 per cent. better than what we are cultivating. There are from 100,000 to 150,000 acres. That is the estimate they put upon it.

The CHAIRMAN. How much do you estimate it to be?

Mr. WHEELER. I do not care about estimating.

The CHAIRMAN. How much better is it than the land that is cultivated, that which we see about Reno?

Mr. WHEELER. Forty to 50 per cent. better. The cost to irrigate that land would not be 10 per cent. of its value. Ours is covered with rocks, and it would cost $30 to $40 an acre to take the rocks off. On this uncultivated land of which we speak you can hardly get a stone to throw at a bird.

Mr. RICKEY. That is the case in every valley in this State. The lowlands which were most accessible to the water were, of course, the first lands settled. That was because they could get water on them cheaper, and they are the poorest lands in all this valley; they are the alkali lands. They are either rock or alkali. When you get back near the bench lands the soil is deeper and much richer. That is my observation all over this State. Get back to the foot-hills in some of those valleys, and it is wonderful to see the crops they produce there.

The CHAIRMAN. It is warmer there?

Mr. RICKEY. Yes; and it is much better for everything.

The committee adjourned to meet on call of chairman.

STATEMENT OF C. W. FRIEND, OF CARSON, NEV.

Under date of Carson City, December 4, 1889, Mr. Friend, chief of the State service, forwarded to the committee the following review, which has been ordered filed for report:

The Nevada State weather service was established in February, 1887, by the following act of the legislature:

AN ACT to establish a weather-service station in Nevada and to provide for the appointment of director thereof, and appropriating money to pay the expenses of the same.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SEC. 1. The establishment of a weather-service station being necessary to secure as complete a history of the weather of Nevada as possible, in order to furnish trustworthy material for a study of its climate, to acquaint the people of the State and non-residents with the physical conditions of every locality, based upon reliable climatic data, thereby greatly benefiting the agricultural, commercial, manufacturing, and municipal interests, there is hereby established at Carson City, in this State, a central weather station, to be under the supervision of a competent director, to be appointed as hereinafter provided.

SEC. 2. The duties of said director shall be to establish volunteer weather stations throughout the State, at least one in each county, and to supervise the same; to receive reports from said volunteer weather stations, reduce the same to tabular form, and prepare and have printed monthly reports, copies of which shall be, by said director, sent to all colleges, high schools, hospitals, public libraries, agricultural societies, and newspaper proprietors who shall in writing request the same.

SEC. 3. Said director shall also prepare an annual report of his labors, and of the work done by the volunteer weather service, and present the same to the governor for publication. Fifteen hundred copies of said report shall be printed by the superintendent of State printing, of which five hundred shall be for the use of the State officers and one thousand for the use of the legislature. The superintendent of State printing shall do all printing necessary to carry out the requirements of this act, and the secretary of state is authorized to furnish said director whatever stationery he may need in the proper performance of his duty.

SEC. 4. Said director shall be appointed by the governor, and, in addition to the other duties required under the provisions of this act, he shall file with the State librarian monthly reports of the meteorological observations provided for in the third section of this act; and the same shall be carefully preserved by said librarian, and be open to inspection during office hours to any one applying therefor. For the performance of the duties prescribed by this act the director hereinbefore mentioned shall receive a salary of six hundred dollars a year, payable in monthly installments, upon the claims being allowed by the board of examiners, and said claims shall be paid as other claims against the State are paid, and shall be in full for all demands of said director, including traveling expenses.

SEC. 5. Said director is authorized to provide for the equipment of such volunteer weather stations as shall be established by him, of which there shall be at least one in each county, at a cost not exceeding twenty-five dollars for each station so established. Each station shall be supplied with the following instruments: One maximum thermometer, one minimum thermometer, one dry-bulb thermometer, one wet-bulb thermometer, one rain-gauge, with overflow attachment, and such other instruments as may be necessary, of which the cost shall not exceed the sum of twenty-five dollars for each station, as hereinbefore provided. Said director shall apply to the United States Central Signal Office in Washington, D. C., to have the weather stations in this State recognized and registered as volunteer stations, auxiliary to the United States Weather Service, and shall also apply for and receive the printed blanks, franked envelopes, and books of "instructions for voluntary observers of the Signal Service of the United States Army," and such other stationery as is usually supplied to volunteer observers. All instruments purchased with State funds by said director for use in any department of the weather service in this State, and all charts, maps, diagrams, and tabulated forms made by him in his official capacity, shall be the property of the State solely.

SEC. 6. For the purpose of paying the salary of the director herein mentioned during the years 1887 and 1888, the sum of twelve hundred dollars is hereby appropriated, out of any moneys in the general fund not otherwise appropriated.

SEC. 7. The sum of five hundred dollars is hereby appropriated, out of any moneys in the State treasury not otherwise appropriated, to be applied in purchasing the instruments provided for in the fifth section of this act.

SEC. 8. The county auditors of the respective counties of this State are hereby constituted volunteer reporters of meteorological observations, and shall keep and record such observations and reports as are required by the provisions of this act and report the same to the director of the State weather service station, and shall perform such duty without compensation additional to that now allowed by law for the performance of other duties of their office.

REPORT.

INTRODUCTION.

The issue of the monthly weather reviews made by the observer of the Nevada State weather service, as provided by law, was begun in February, 1888. The first stations were established in September, 1887, and observations were begun on the 1st of October following. One station was established in each county, the county auditors, by act of the legislature, being constituted *ex-officio* State weather observers. Other stations have since been added to the list. The total number of stations at present from which reports are received is thirty-eight. Of these four are rain-fall stations, located at the following places: Cherry Creek, White Pine County; Burner's Ranch, Elko County; Crane's Ranch, Elko County, and Secret Valley, Elko County.

Many difficulties have beset the work of organizing the State weather service, and the outlook at first was not at all encouraging, but through determined effort and a deal of labor the service has assumed proportions and given promises of success far exceeding the most sanguine expectations of its friends and promoters. A very considerable degree of interest has been aroused among the people in various parts of the State in the study of our climate, and a disposition is manifested to make such study profitable by making intelligent application of the knowledge thus acquired. The United States surveyor-general, Mr. C. W. Irish, has rendered the service very valuable assistance, and its present status is largely due to him.

The Chief Signal Officer has very kindly rendered us all the aid in his power, and caused the daily weather indications to be telegraphed to all important towns in the State requesting the same. In order that the indications might be generally known and more beneficial to the people of the towns at which they are received, it was decided that a display of signals be made. This display of signals has been made at Carson City since October 4, 1887, and has given general satisfaction to the citizens of that place and vicinity. The signals consist of a set of four flags, the cost of which is very small, and it requires but a few minutes' time each day to make the display. These weather indications, received for the past year, have in nearly every instance been verified, and there is good reason to hope that they will ultimately be of great benefit to the State.

It is hoped to secure the service of at least one efficient observer in every county of the State. One of the provisions of the law of 1887 makes it the duty of the several county recorders to make the necessary observations and report the same; but it was a duty imposed on these officers after they had gone into office, and in many cases has been disregarded. There is no reason why this duty should not be as imperative as any other imposed by law.

The object of the weather service is to observe and utilize every feature of the weather that affects the prosperity of the inhabitants as to crops, health, life, etc., omitting, perhaps, only those few items already provided for by the General Government at Washington, such as general predictions. The State service is, therefore, essentially a plan for gathering and utilizing local climatic data, and eventually it will define precisely the locations most favorable or unfavorable to special crops, diseases, etc. Some of the advantages derived from a State weather service are as follows:

It will enable the Chief Signal Officer at Washington to trace upon charts all the atmospheric changes that occur in the State, and from such data make it possible to forecast the weather. It will give to every county the Government standard of temperature, rain-fall, humidity, etc., which is useful information. It will educate the people in the physical and climatic conditions of the country in which they live. It will put within reach of the local agricultural societies means of accurate observations which, in the course of years, must be valuable to any locality in the object of their pursuits. It will form reliable records in legal cases. It is invaluable to the State bureau of immigration, as it will invite immigration, by publishing the reports and showing the climate of the State. It will aid the medical profession in the study of diseases. It will show to the whole United States the large amount of water, by actual figures, that there is in the State, and be a basis for Congress and our legislature to convert thousands of acres of otherwise waste lands into beautiful and profitable farms and gardens, and it will show thousands of people who are dying in various humid parts of our country where they can prolong their lives and, in many *cases,* live to a good old age.

IRRIGATION.

In this connection I deem it both relevant and proper to specially refer to this very important subject. While I realize that water is a precarious element, wherever irrigation is necessary, other States have been able to enact effective and satisfactory laws governing the distribution of water for irrigating purposes, and I see no good reason why Nevada should not do likewise.

The desert region of Nevada is only a desert when deprived of water, the soil being generally productive when irrigated, and the amount of land capable of being brought under cultivation is only limited by the water supply.

The rain and snow fall is much greater in the mountain than in the valley districts; more particularly is this the case along the eastern slope of the Sierra Nevada range of mountains. Truckee, Carson, and Walker Rivers have their source in these mountains of perpetual snow, and give the western portion of the State its only trustworthy supply for irrigating purposes.

During the months of April, May, and June these streams overflow and endanger land and property in the valleys through which they flow. In these spring floods immense bodies of water pass uselessly by, not being needed at that season of the year. Scarcely is the débris cleared away from the rush of water, when in August, September, and October a season of drought sets in and a general water-famine prevails.

Good authorities estimate that 80 per cent. of the annual discharge of these streams passes down during the months of April, May, and June, and not more than 10 per cent. in August, September, and October. This 10 per cent. is subject to excessive loss from evaporation (owing to the smallness of the streams and consequent sluggish flow), which, added to the wasteful manner in which it is used by persons intent on securing their own advantage, reduces the amount judiciously appropriated at least one-half more.

It is safe to estimate that there is sufficient precipitation in western Nevada and its adjacent water sheds, if properly disposed of, to increase the area of land now under cultivation tenfold. The importance of saving these waste waters, and the great benefits which would inure to the State by a successful solution of the problem of storage and distribution, needs no amplification.

CLIMATE.

On the whole, the climate of Nevada can not be surpassed in the United States. In the winter there is just cold enough to destroy the insects and the effects of decaying vegetable matter, and in the summer just heat enough to ripen vegetation and give a vigorous growth to all animal and vegetable life. The nights are always cool and refreshing during the hottest months of summer. Thousands of people are dying in Oregon and in the Eastern, Southern, and Northern States because they have not a Nevada atmosphere to breathe.

The State bureau of immigration alludes to our climate as follows:

"The climate of Nevada is the most delightful and salubrious in the known world. Neither the prostrating heats and destructive cyclones, nor are the Arctic frosts and deadly blizzards of the Western States known here. The consumption-breeding fogs and countless insect pests that swarm in other lands are also strangers in Nevada. The warmest days of summer are modified by soft southwest winds, laden with the sweet odor of wild flowers and the invigorating aroma of the indigenous sage, while the nights are seasons of transcendent loveliness, rendered so by the gentle mountain breezes that waft health and vigor to the sleeper. In June and July occasional thunder storms cool the air and freshen the face of nature. The winters, with the exception of a few cold days, are spring-like, the snow remaining only a short time, except at great altitudes. Malarious fever and pulmonary consumption are exceedingly rare, and are usually imported cases, while smallpox, measles, and kindred diseases are shorn of their terrors by the dryness and purity of the atmosphere. Scrofula, salt rheum, and similar inherited taints of blood are, in a few years, almost entirely eradicated from the system by the wonderful healing properties of Nevada's matchless climate. Nevada may be justly styled 'the world's great sanitarium.'"

PRODUCTIONS.

Nevada extends from the thirty-fifth to the forty-second degree of latitude; consequently her productions are necessarily varied and embrace wheat, barley, oats, alfalfa, all variety of garden vegetables, cotton, tobacco, almonds, figs, grapes, etc. It is one of the few States that can produce both apples and peaches of excellent quality. Currants are produced in abundance and are a sure crop.

Concerning the tropical portion of Nevada, read what Mr. D. Bonelli, observer of Rioville, Lincoln County, says: "I settled here in 1868, first at St. Thomas, 25 miles

north of here, where the thermometer would go to 123 in the shade and 156 in the sunshine. This temperature will hatch out eggs left in the cupboards in the houses, if they get an occasional movement, and it will steep tea in the sun and boil eggs in sand exposed to the sunshine, though it will not melt lead. The excessive heat, of course, limits the range of vegetation, and makes it necessary to grow grain in the winter. It is sown in October and November and ripens the first of May. Figs are ripe by the middle of May; almonds full grown last of April; grapes ripen the last of June. Snakes, lizards, horn toads, and tarantulas take a sort of hibernating spell in the hottest weather for a month, and are extra active about February and March, by which time our main forage crop, lucerne or alfalfa, is growing. It is cut by the middle of April, and five additional crops are cut if water be plentiful. The articles mentionod are the main productions that will stand the climate; everything else languishes in the summer-time. I am now getting some esparsette to try, a European forage plant that does well in dry and hot soils there and may prosper here.

"This region is sparsely settled, since there are only a few margins of arable land along the streams and transportation facilities are lacking to market the products. Railroads come near enough to spoil the produce market we used to find in mining camps, and not near enough to take off our surplus. If there is nothing found suited to the climate that will pay to export, and no mineral discoveries of value are made, it will only be the question of a few years when the white man must disappear from this region in spite of the many efforts made in the past for its settlement. If anything exists in nature that is valuable for food, clothing, or medicine that requires just such a climate, it would be charity to introduce it."

INSTRUMENTS.

The instruments in use by the observers of the Nevada State weather service are the maximum and minimum thermometers and the rain gauge, and at a few stations the dry and wet bulb thermometers are added, all of which are standard and of uniform pattern.

Full instructions for using and properly exposing the instruments are furnished to observers from this office, but as a rule not strictly carried out, and it is very essential that in order to ascertain as nearly as possible the temperature of the air proper instrument shelters of cheap construction and modern pattern should be provided for the stations. It would also be advisable to supply a few stations in different parts of the State with self-recording barometers and thermometers.

OBSERVERS.

Much credit is due to the many good observers, whose untiring efforts have brought regularly carefully compiled reports without the slightest compensation for their efforts.

The following is a complete list of persons reporting to the State service:

Station.	Observers.	Station.	Observers.
Leonard Creek	N. W. Derby.	Lewers' Ranch	Miss Kate Lewers.
Palisade	J. L. Fast.	Virginia City	Mark Averill.
Tuscarora	Prof. M. D. Bowen.	Dayton	Prof. Robert Lewers.
Winnemucca	John P. Slaughter, Sig. Corps.	Carson City	C. W. Friend.
Gold Mountain	H. H. Robinson.	Ely	J. F. Cupid.
Elko	C. H. Sproule.	Genoa	G. W. Dungan.
Mill City	J. A. Ferraro.	Sodaville	T. T. Keay.
Humboldt	Samuel H. Kitto.	Downeyville	Dutton Fowler.
Beowawe	Ira G. Hoag.	Belmont	John Reynolds.
Punch Bowl	I. G. McMonigal.	Hawthorne	George Garrison.
Crane's Ranch	W. T. Crane.	Candelaria	W. H. Shockley.
Burner's Ranch	Prof. J. F. Burner.	Pioche	N. P. Dooley.
Ruby Hill	W. B. Lawler.	Rioville	Daniel Bonelli.
Hot Springs	Miss L. Merrill.	El Dorado Cañon	P. W. Davis.
Reno	W. S. Devol.	Keeler, Cal	D. C. Grunow, Signal Corps.
Verdi	C. R. Carter.	Cedarville, Cal	Jackey and Drouillard.
Furguson's Ranch	J. W. Furguson, esq.	Younts' Ranch	Harsha White.
Austin	O. B. Vincent.	St. Clair	L. Allen.
Eureka	M. M. Ley.	Pyramid Agency	Rodney and Richardson.

This is a work that all ladies should take a great interest in, especially as they can do the work well, and generally more conscientiously than the "Lords of Creation." The Signal Service observers render us very valuable assistance.

A Review of the Weather for Ten Months in 1889.

JANUARY.

The first eleven days of the month were characterized by warm, sun-shiny weather and a total absence of precipitation; from the 12th to the 18th there was a period of cold and rainy weather, nearly all of the precipitation for the month occurring between these two dates, but more particularly on the 18th, on which date thirteen out of a total of twenty-four stations reported precipitation in amounts ranging from .03 at Beowawe to .86 at Tuscarora. The remainder of the month was attended by clear and warmer weather, with very little precipitation. The highest temperature during the month, 64.8, occurred at El Dorado Cañon on the 17th, and the lowest temperature, 22, at Elko on the 17th, the absolute range of temperature for the State being 86.8.

Nearly all of the lowest temperatures reported occurred between the 16th and 20th, during the prevalence of a severe cold wave.

The greatest daily range of temperature, 66, occurred at Elko on the 20th, and the least daily range, 6.5, at Eureka on the 14th.

FEBRUARY.

A summary of the weather conditions during the month, compiled from reports received from twenty-three stations, shows that the mean temperature for the State, 33.6° Fah., was slightly colder than the average February temperature, 36.4. Eldorado Cañon, in the extreme southeast portion of the State, reported a temperature of 75.2 on the 28th, the highest for the State. The lowest temperature, 11° below zero, occurred at Elko on the 1st, making the absolute range for the State 86.2°. The weather was generally clear. It was coldest in the northern part of Eureka County, in the vicinity of Beowawe, and was warmest in the southern part of Lincoln County, around El Dorado Cañon, the mean monthly temperature at the latter place, 55.2, being about 3 degrees warmer than that of San Francisco and nearly 5 degrees warmer than that of Sacramento, Cal.

Precipitation (including rain and melted snow) was reported from twelve stations, six of which in the extreme western and six in the northeastern and eastern portion of the State, the average fall for the State, .37 of an inch, being but little more than half the average for the same month last year. The largest amount of precipitation which fell at a single station in any twenty-four consecutive hours was .64 of an inch at Ely, on the 15th. Pioche reported the largest monthly rain and snow fall, .79 of an inch. Although 26 inches of snow fell in the southern part of Elko County and 12 inches in the northeastern part of Lincoln County, yet Pioche is the only station at which snow was reported as being on the ground on the last day of the month.

MARCH.

The weather was generally clear and warmer than usual. The mean temperature for the State, 44.1, as deduced from reports received from twenty stations, was 2.5 degrees higher than the average March temperature. The highest temperature, 85.1, occurred at El Dorado Cañon, in Lincoln County, on the 29th, and the lowest temperature, 12° above zero, occurred at Elko, Elko County, on the 31st, and also at Wellington on the 19th, making the absolute range for the State 73.1°.

Unlike the preceding month, very heavy rains fell generally throughout the State, particularly in Douglas, Lyon, and Ormsby Counties; also in the southern part of Washoe, and the southeastern part of Elko County. The monthly rain fall at some of the stations in the above-named counties was unusually heavy for this time of year. Although snow fell in Humboldt, Elko, Eureka, White Pine, Douglas, and Lincoln Counties, yet nearly all of the precipitation reported occurred as rain.

APRIL.

The past month will long be remembered as an exceedingly dry and generally windy one; the average temperature for the State, 53.5, as computed from twenty-four reports, was about normal; the days were generally clear to fair. El Dorado Cañon reported the highest temperature, 100.2, on the 26th, and Eureka reported the lowest temperature, 15.5° above zero on the 18th, making a total range for the State of 84.7°. The highest temperatures nearly all occurred during the warm period of the 24th to 27th, while the lowest temperature occurred from the 14th to 18th.

The rain fall was greatly deficient at all stations except Burner's Ranch, in the southeastern portion of Elko County, and at Pioche, Lincoln County. The average for the

State, .45 of an inch, is less than the normal. At the majority of stations observers reported crops of all descriptions suffering greatly from the persistent drought. Very few stations reported any snow-fall during the month, and when it is considered how little snow yet remains in the mountains the prospects are discouraging to agriculturists and mill men.

MAY.

The remarkable features of the weather during the past month were the heavy storms of the 5th to the 8th, and 15th to the 17th, the remainder of the month being attended with fine spring-like weather. The storm on the 5th, which was general throughout the State, is the heaviest on record for the past ten years, and was characterized by unusually cold weather and very heavy rain-fall in all sections. The mean temperature, 57.8, was a trifle below the average. The warm periods were from the 24th to the 29th, the highest temperature for the State, 106, occurring on the 28th and 29th at Eldorado Cañon. There were two cold periods, from the 6th to the 8th and from the 15th to the 17th. The lowest temperature reported, 20 degrees above zero, occurred at Wellington on the 8th, and also at Ruby Hill on the 16th. The total range of temperature between the warmest and coldest stations was 86 degrees.

The rain-fall throughout the State was greatly in excess of the average, and was particularly so in the northern and western counties. The long-continued drought which threatened this section of the country for some time past has at last been broken; the aspect of the country has been entirely changed, and crops of all kinds have been materially improved. The prospects are at present more encouraging than they have been at any time this season.

JUNE.

The month was attended with fine, clear, pleasant but rather dry, weather, particularly so in the central and southern counties. There were no general storms during the month, the only atmospheric disturbances being in the shape of thunder and hail storms in different parts of the State. The mean temperature for the State, 70 degrees, was slightly above the normal for this month. There were two very warm periods, from the 24th to 26th, and from the 29th to the 30th. The highest temperature for the State, 110, was observed at Eldorado Cañon on the last day of the month. Between these two warm periods there was a cold one, from the 27th to the 28th. The lowest temperature reported was 30.5, at Tuscarora, on the 2d, making the absolute range of temperature for the State 79.5 degrees.

The average rain-fall of the State for this month indicates a deficiency of .10 of an inch. The rain-fall was heaviest in Elko and Douglas Counties and least in Lincoln County. The effect of the drouth is again being felt in all sections; farmers and millmen complain of the scarcity of water in the streams, which are lower now than for several years past.

JULY.

The weather during the past month has been unusually warm in all sections of the State; there was a very large percentage of sunshine, each station having an average of a little over twenty-four clear days. During the last few days of the month smoky and hazy weather prevailed to a considerable extent all over the State. Two well-defined warm waves passed over the State, the first from the 30th to the 5th, and the second, which was by far the most intense, from the 27th to the 30th. Nearly all of the highest temperatures reported occurred on the 29th.

The mean temperature for the State, 76.1, is only .5 of a degree higher than the average, but the number of stations which reported maximum temperatures above 100° this month is far greater than that reported during the same month last year. The temperature ranged from 119 at Eldorado Cañon, on the 27th, to 36.0 at Elko, on the 16th, or 83°.

Precipitation.—There were no general and but very few thunder and hail storms during the month. The rain-fall, which was very small and much below the average, was very unevenly distributed, and fell chiefly in the southwestern part of Elko County, central portion of Esmeralda County, and in Lincoln County. The total absence of rain in the remainder of the State has greatly injured crops of all descriptions. Farmers are complaining of lack of water in streams and springs, and predict a hard time for themselves and the cattlemen. Cattle all over the State are suffering from this disastrous drought. Of twenty-nine reporting stations this month, only five reported *rain,* while during the same period last year rain fell at nineteen out of a total of *thirty-three stations,* and was well distributed.

AUGUST.

The temperature during the past month was about normal. The mean temperature for the State, 73.2, is only .9 of a degree lower than that of the same month last year. The atmosphere was generally smoky and hazy all through the month. The hottest monthly mean temperature, 95.5, is that of Eldorado Cañon, and the coldest monthly mean, 62.0, at Ely. There were two warm periods, the first from the 1st to the 3d, and the second from the 14th to the 16th. The majority of the lowest temperatures recorded occurred during the cold period of the 18th to the 20th. The highest maximum temperature for the State, 117.3, occurred at Eldorado Cañon, and the lowest minimum temperature, 29.0, occurred at Elko on the 29th. The range between the two extremes for the State is 88.3 degrees.

Precipitation.—The disastrous drought was broken in portions of Eureka and Elko Counties, in Esmeralda, Nye, White Pine, and Lincoln Counties, but still continues in other counties. Rain fell at thirteen out of a total of twenty-eight stations, with an average rain-fall for the State, this year, of 1.06 inches, which is .45 of an inch more than that of the same month in 1888. Thunder-storms were frequent at Belmont, Nye County, and Pioche, Lincoln County, and were attended with heavy rain-fall. Frosts occurred at Crane's ranch on the 20th, at Pioche on the 29th, and at Ruby Hill on the 20th, doing little damage. The supply of water for irrigating and milling purposes is still very short all over the State.

SEPTEMBER.

September will go down in the meteorological annals of Nevada as an exceedingly dry and comparatively cool month. There was an average of twenty-three cloudless, four partly cloudy, and four cloudy days for each station. The mean temperature for the State, as deduced from twenty-three monthly reports, 61.7, is nearly 5 degrees below the normal, and about 10 degrees cooler than that of the same month last year. Eldorado Cañon reported the highest temperature, 110 degrees, on the 6th, and also the highest mean maximum temperature, 97.4. The lowest temperature for the month, 13 degrees above zero, occurred at Elko, which station reported also the lowest mean minimum temperature. There were two warm periods during the month, the first from the 3d to the 7th, inclusive, and from the 28th to the 30th, inclusive, and two cold periods, from the 11th to 14th and 22d to 24th, respectively. The atmosphere was smoky and hazy in many portions of the State, owing to extensive forest fires which were raging during the month, causing a great loss of timber. Frosts were reported from a number of stations throughout the State on the 12th, 13th, 14th, 24th, and 25th, doing little damage to vegetation.

Precipitation.—Excepting a few favored localities, the effects of the terrible and long-continued drought were felt all over the State during the month. Rain fell this year at only seven out of a total of twenty-four stations, principally in Elko, White Pine, Nye, Esmeralda, and Lincoln Counties, while this month last year rain was reported from twenty-three out of twenty-four stations, and was well distributed. There were no general or extensive storms during the month. On the 19th and 20th thunder storms, accompanied with rain, occurred in the above-named counties. Many mills have shut down, owing to the scarcity of water in rivers all over the State, and will remain so until November, unless heavy snow-storms occur before then. Cattle-men are despondent. Cattle are in such condition that an inclement winter will kill thousands of them, and if the coming winter is an open one, with but little snow, they will starve next summer. The average rain-fall per station was .55 of an inch. The largest amount of precipitation which fell at any one station during the month was 2 inches, at Pioche. No snow fell during this month.

OCTOBER.

The temperature during the month was about normal all over the State. The average, as deduced from twenty-six reports from all over the State, is 52.2. There was an average of ten cloudless, nine partly cloudy, twelve cloudy, and six rainy days per station. The highest temperature reported was 103, at Eldorado Cañon, on the 4th, and the lowest temperature was 14 degrees above zero at Ely, on the 28th. There was a well-defined warm period from the 4th to the 6th. The highest temperature at nearly all stations occurred on the 4th. The three last days of the month were very cold all over the State. The extensive and destructive fires which were raging during September and part of October, obscuring the atmosphere to a great extent, were extinguished by the general rains during the latter part of the month. Frosts were general all over Nevada on the 8th, 9th, 10th, 11th, and from the 24th to the 31st.

Precipitation.—The terrible drought has at last been broken. The rain-fall during the month was generally unusually heavy in all counties except in the southeastern portion of Humboldt County, and in Storey and Churchill Counties. It was well distributed throughout the State, as will be shown by the fact that an average of 1.48 inches of *precipitation fell at* every reporting station in the State. The average

rain-fall for the State, 1.48, is 1.11 inches higher than that of October, 1888, and .56 inch in excess of the normal. Rivers and streams throughout Nevada have risen somewhat, but are still low. Some of the mills in the mining regions have resumed work. The general aspect of the country was considerably changed by the generous rains. Nearly all of the precipitation reported was in the form of rain. Snow fell at Tuscarora, Burner's Ranch, Eureka, and Virginia City, ranging in amount from 2 to 11 inches. There was no snow on the ground at any of the stations on the last day of the month. Taken all in all, the weather conditions during October have been very favorable, and farmers, cattle, and mill men are in consequence jubilant, the prospects being better at present than they have been for several months past.

STATEMENT OF T. D. PARKINSON, OF FAIRLAWN.

[In relation to the water storage system of the Nevada Land and Cattle Company.]

In response to the committee's request I furnish a report of our works and what had been accomplished. The report it is hoped will be of practical value. A brief history of our works is embodied, as it is (as Senator Stewart reports) the first step taken in America for the reclamation of arid lands by water storage. I therefore submit the following:

Squaw Valley is located in Elko County, Nev., at an elevation of 5,100 feet above sea-level. The valley lands embrace an area of about 30,000 acres. Like the generality of valleys lying within the State, the soil is exceedingly fertile, but entirely unproductive on account of the aridity of the climate.

The valley is surrounded by high mountains, which are covered with snow for about six months in the year. During the spring and early summer months large bodies of water, created by the melting snow, course through the various channels in the mountain cañons and, concentrating in Willow and Rock Creeks, are exhausted in the Humboldt River and its "sink."

The difficulty this State and many other arid districts labor under for the cultivation of its soil is the light rain-fall that takes place in the spring months, and the exhaustion of its waters from the melting snow at a period too early for irrigation. Nature, however, seems to have provided a way to overcome this difficulty in placing in its numerous cañons natural sites for dams whereby the husbanding of water by storage enables the apparent worthless land of its valleys to be made productive by irrigation.

At the point where the Willow Creek debouches into Squaw Valley is a natural reservoir embracing fully 2,000 acres. At its outlet is a narrow defile in the foot-hills of the mountains. The rock bluffs at this point are about 100 feet in height and about 175 feet apart.

The Willow Creek Dam and the storage reservoir thus described presents these features:

As this enterprise was entirely experimental, and probably the first of its kind in America, the uncertainties attached to it were too great to justify a very extensive outlay.

In the construction of the dam no masonry was used; the retaining wall is simply loose rock dumped into the cañon from the adjoining bluffs, the rock allowed to take its natural slope, forty-five degrees. The upper face of the revetment is covered with a sheathing of plank three inches in thickness, the joints of which are securely calked with oakum, and the face then covered with heavy felt asphalt roofing.

The sheathing laid horizontally is securely spiked to 8 by 8 timbers placed 4 feet apart. To guard against the danger of an undermining *of the foundation*, which is the most serious difficulty in dam construc-

tion, particularly where great depth of water is obtained, a pit was sunk through the clay to solid rock, thus joining the two bluffs.

The expense attending the construction of this pit, on account of the large body of water encountered with quick-sand, was great, and its abandonment at times thought advisable, which idea I am happy to state was not carried out. The bed-rock having been secured in this pit, the sheathing before spoken of was started upon it, and carried up to the foot of the rock embankment and thence to the top of the dam. As a question may arise as to the durability of these foundation timbers, I will state timber subjected to moisture alone, free from air, will remain intact for years.

The present size of the dam (September, 1889) is as follows:

	Feet.
Height from bottom of cañon	50
Width on top	20
Width of rock bank at base	120
Length on top	175
Length at base	125

The sheathing is covered by earth to a height of about 20 feet and carried back about 100 feet, making the entire width of dam at base about 220 feet. The cost of dam, tunnel, and gates was about $35,000.

The Tunnel Waste-Gates and Supply-Gates.—Seldom, in the construction of enterprises of this kind, have been found so many natural advantages as possessed by the site of the Willow Creek Dam.

In a country like that of Nevada, where rain seldom falls, water spouts or "cloud bursts" frequently occur, and to guard against any disaster that might occur by their visitation, water-ways must be constructed to take the overflow. Again, in our case, the spring freshets occasioned by the melting of snow on the plains and mountains is severe, making a mountain torrent of Willow Creek. The subjection of our dam to this sudden pressure is objectionable, and to allow the water to accumulate slowly is advisable. Few dams, however, can allow this, as the surplus water can only be discharged through weirs over the dam. The north bluff of the Willow Creek Cañon, consisting of a spur of the mountain only 80 feet in width at the base, a tunnel was constructed through it with a cross-section of 10 by 10 feet with its base on a level of that of the base of the dam. This channel, it will be readily seen, is amply sufficient for the greatest flood that might occur. The area covered by this water storage, with a depth of 50 feet at the dam, embraces about 500 acres; as the bottom of the reservoir is a plane surface the average depth can be assumed at 25 feet, thus containing 544,500,000 cubic feet of water, sufficient to cover 12,500 acres 1 foot in depth.

Irrigating capacity of this body of water.—No definite rules have as yet been established in irrigation to form any base for calculating the amount of water 1 acre of land requires per season to produce a crop of grain or hay. The system of producing crops by irrigation, though now carried on extensively in California, may be said to be in its infancy. Each irrigating district has been found to have its peculiar advantages or disadvantages, but so wide has been the difference in the amounts of water required per season no uniform base for calculation can as yet be established. This can be readily understood when it is apparent that in such calculation character of soil, natural moisture, humidity and evaporation must be taken into consideration. Practical experience alone can only be the guide.

In our case it is only after a series of irrigating seasons can such a base be determined upon. This conclusion was forcibly impressed upon

me, from my experience in the irrigation of our alfalfa fields this past season, as this question of water supply is all important to the success of our enterprise. I will briefly give my experience in the irrigation of the Rock Creek Ranch this past season, leaving it to the minds of those interested to draw their deductions. With this relation could also be given the experience of the larger irrigating enterprises of California which are familiar to me, but the subject is too exhaustive to enter into in this report.

Rock Creek ranch is situated about 10 miles from the Willow Creek dam, about 175 feet below the base of the reservoir. The water taken from the reservoir follows the channel of Willow Creek 2 miles, thence by ditch 8 miles, to the Rock Creek Valley. The flowing capacity of the completed portion of this ditch at present is about 3,333,000 cubic feet of water per twenty-four hours, though but 1,500,000 cubic feet was allowed to flow through it last year. The irrigable land lying under the Willow Creek reservoir embraces an area of about 15,000 acres.

The soil of Rock Creek Valley is of the richest character, comprising the deep black alluvium of the low-lands and the yellow, gravelly loam of the mesa or upland. The former is well adapted for the cultivation of the finer grasses and cereals, while the latter, being of a warmer nature, is better fitted for alfalfa. The annual precipitation of moisture in this State is light, and in Squaw Valley rain seldom falls, though snow is sometimes found 1 foot in depth; it falls in the winter when the ground is frozen and incapable of taking the moisture by its melting. The mesa ground in particular is very dry, the moisture seldom penetrating 8 inches below the surface.

At the commencement of the irrigating season, I was greatly surprised to find the amount of water that was being used on our fields, but when the dryness of the soil was taken into consideration, with the rapid evaporation that must be going on under a summer sun, this apparent loss was accounted for. It was with no little anxiety the daily decrease in the reservoir was witnessed, and grave fears were entertained that a storage capacity could be obtained sufficient to warrant a large acreage of alfalfa. On estimating the daily flow distributed per acre, it was found to be so enormous investigation was made, and on an examination of wells, sloughs, and other depressions in the neighborhood of the irrigating sections, water or moisture was found within a few feet of the surface where before 8 to 10 feet it was encountered.

In one instance a well was sunk 50 feet before water was encountered, the position of the well being about 1 mile from the irrigating fields. In ten days after the irrigation of a field about one-half mile distant the water in the well rose to within 8 feet of the surface and remained in this position for months after irrigation had ceased. It is a well-established fact that the soil when once thoroughly moistened will retain its moisture for a long period of years, the surface alone becoming dry. This is proven to be a fact in the great irrigating plains of California, where formerly nothing could be produced, now yield large crops of alfalfa without irrigation.

Evaporation.—In an arid climate like that of Nevada, where there is but little humidity in the atmosphere, evaporation is excessive, shallow bodies of water evaporate faster than those of greater depth. From this we may expect less proportionate loss of our water storage, as greater depth is attained by the raising of the dam. The greatest loss by evaporation is found in the irrigation of new land. The mesa land of the Rock Creek Valley, when turned by the plow, resembles an ash-heap, and exposed to the temperature of a summer sun retains heat

sufficient to often blister the feet of the plowman. This excessive evaporation takes place only during the first year of alfalfa cultivation. On the second year the surface of the ground has become solid and compact, the plant in the first season being seldom cut, the natural moisture of the ground is retained, and before irrigation is required the plant has obtained sufficient growth to protect the ground from the sun, and thus lessening the amount of evaporation in a great degree.

Though the irrigating capacity of the Willow Creek reservoir when full will, no doubt, in time be far beyond the present estimate, placed at 6,000 acres, which at the best can be but approximate. It has not been deemed advisable by the owners to advance the irrigating fields yearly beyond a certain limit, that the great basin, naturally very dry, in which their fields are located, may become first thoroughly moistened, thereby enabling the alfalfa, which is the principal crop raised, in case of drought or shortage of water, to find natural moisture sufficient to survive a dry season.

Present area under cultivation.—There are at present about 1,500 acres of land lying under the main canals that are seeded to alfalfa, or grain and lands ready for cultivation. On account of the droughts which have occurred for the past two years, the progress of the work has been considerably retarded, yet the result of prosperous years has been so satisfactory—ample proof has been presented—that the enterprise entered upon as an experiment is no longer one of doubt, but a success, and plans are being carried out to complete the work of reclamation to the full extent of the water storage and to the construction of another dam.

At the present date there has been constructed upon this ranch about 22 miles of main supply ditch, the size of which average 3 by 12 feet, with a carrying capacity of about 3,333,000 cubic feet per twenty-four hours, sufficient to cover 300 acres with 3 inches of water per twenty four hours.

The chief crop that is cultivated upon this ranch is alfalfa, which is fed to beef cattle and for winter provision for breeding stock. Grain is also raised, but only for farm purposes. Two crops of alfalfa are produced annually, yielding for the season about 4 tons per acre, though on choice ground, when great care has been used, as high as 4 tons per cutting has been obtained.

Vegetables of all kinds, suited to the latitude, are produced in abundance, a failure in the crop being unknown; as high as 550 bushels of potatoes have been gathered in one season upon 1 acre of land.

STATEMENT OF J. W. HAINES, OF DOUGLAS COUNTY.

[On behalf of a committee of citizens.]

The following facts are submitted in regard to our irrigating interests as well as the same interests in Churchill, Lyon, and Ormsby Counties, through which Carson River flows. It is the source from which our lands are principally supplied with moisture. Our valley, known as Carson Valley, in Douglas County, Nev., has an area of 25 miles in length, and an average width of about 10 miles. Carson River heads in Alpine County, Cal. It has there area of about 5 miles in length, and from 3 to 4 miles in width. In Churchill and Lyon Counties, within this State, it has an area of about 60 miles in length, and from 4 to 10 miles in width. In Ormsby, the area is about 4 miles in length, and 1½ miles in width. About one-fourth of the above area is now being irrigated, using less than two-thirds of the water required for a full crop. Therefore, the loss is equal to one-third

on the land now under cultivation. We think that with a proper amount of moisture we can safely say that all of the above area is capable of producing first-class crops of wheat, from 20 to 30 bushels per acre; oats, 35 bushels; barley, 30 bushels; alfalfa hay, from 4 to 6 tons; timothy, 2½ tons; clover and other grasses, 1½ tons per acre. Potatoes and other root crops yield equal to or superior in quantity and quality, when cultivated with the same care and attention that they receive in the Eastern States.

We have an abundance of water falling during the twelve months to supply us with all the water required for all purposes on the above specified area of land to enable us to raise a first-class crop yearly. We have first-class locations for reservoirs, and by utilizing them for impounding surplus waters during the wet season, many thousands of acres situate in the low hills and adjoining valleys may be brought under cultivation and add to the resources and wealth of our State. These waters may be held when safely impounded, from June 1 to September 1, to be utilized when required at least three or four months in each year. Col. Lyman Bridges, a civil engineer of the U. S. Geological Survey, will report fully on our great advantages in the way of storing waters to be used during the three months above specified. We usually have sufficient water to furnish all the moisture required up to June 1 for all the area specified in the different counties. In excess of what we now have we require the storing of water in the available localities which our mountains possess. The area of good lands for farming purposes could be increased many thousand acres if they were made available by the use of water so impounded.

STATEMENT OF DWIGHT E. HOLLEY, SECOND LIEUTENANT, FIRST INFANTRY, U. S. ARMY, FORT McDERMIT.

The soil of this part of the country is excellent, and when properly irrigated is very fertile, while without irrigation nothing thrives upon it but sage-brush. The valley of Queen River is some 60 miles in length by 12 to 16 miles in width. No land except that bordering on streams is cultivated for any purpose on account of the scarcity of water during the irrigating season. The valley slopes gently towards the south. The fall from the foot-hills on either side to the center of the valley is from 20 to 50 feet.

At the extreme northwestern part of the valley is Oregon Cañon, which would be capable of storing a large quantity of water. On the western side of the valley, and nearly west from this post, is McDermit Cañon, the mouth of which is about 70 yards in width, and the sides are vertical walls nearly 200 feet in height. The cañon widens towards the west, and has an average width of perhaps 200 yards. Queen River Cañon, in which this post is situated, has a narrow point about a mile east of the post. At this narrow point the cañon is some 30 yards in width, with rocky walls of about 100 feet in height. East of this the cañon widens considerably. In ordinarily moist seasons both McDermit Creek and Queen River furnish by far the greater part of the water supply for the southern half of the valley.

While it is impracticable to estimate the quantity of water that could be stored, or the amount of land that could be reclaimed, it is evident even from a casual observation of these cañons that a sufficient acreage of land could be reclaimed by storing this waste water to amply repay for the expenditure of constructing reservoirs at the points mentioned.

CALIFORNIA DIVISION.

SAN FRANCISCO, CAL., *August* 26, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman), Jones, and Reagan; also Director Powell.

The CHAIRMAN. The Committee on Irrigation of Arid Lands of the Senate is here to take testimony of such witnesses as may desire to appear. We wish information on the subject of irrigation, how it is conducted in California, and how it can be facilitated. We understand that you have had a good deal of experience in this State, and that you have made preparation to furnish us the desired information.

STATEMENT OF M. M. ESTEE, OF SAN FRANCISCO.

Mr. Chairman and gentlemen, the State Board of Trade some months ago received, and I also received, a letter from Mr. R. J. Hinton, irrigation engineer of the U. S. Geological Survey (who of course voiced your wishes), asking for information. Pursuant to that request, and pursuant to the request made by you, Mr. Chairman, at a previous meeting of the board of trade, it appointed a committee to take into consideration the questions which you are now investigating. That committee, composed of nine members of our board, and representing different parts of the State, made a report in writing, which is now in print. It represents, we think, the views of the best-informed people of this coast, so far as it goes.

This report was not intended to be a "boom" pamphlet, nor was it intended to be full of technical knowledge. That comes from the surveyors, and from the distinguished people whom you will examine. It was intended to show a bird's-eye view of California, so far as it relates to the question of irrigation—to present the necessities of our people for irrigation, the extent of our water-shed, the amount of water we have for that purpose, the amount of land that can be practically and successfully irrigated, the results of irrigation so far as it has been practiced, and also the necessity of having certain surveys made whereby catchment reservoirs may be established in certain places. That report I now present to the committee.

RECLAMATION OF ARID LANDS BY IRRIGATION.

The questions presented are:

What is the physical condition of California so far as it relates to irrigation?

What amount of irrigable land is there in the State?

What amount of water can be obtained for the purpose of irrigation?

What are the advantages of irrigation?

In this connection, does irrigation pay?

What is the condition of irrigation as at present practiced in California, and what interest has the National Government in the subject of irrigation on the Pacific coast and in relation to all that extent of country known as the "arid region" which lies west of the Missouri River?

I.—The Physical Condition of California and its Adaptability to Irrigation.

California lies between the thirty-second and forty-second degrees of north latitude; it has a coast line of over 900 miles, and in width is from 150 to 200 miles, and has an area of 157,801 square miles. Two ranges of mountains extend north and south through the whole length of the State. The coast range, which lies just back of the ocean, parallels its shore line from one end of the State to the other. In many places it is but a range of low hills covered with timber and open pasture lands, while in other places great valleys cut wide swaths through the hills to the sea, like the Salinas Valley, Santa Inez and Santa Ana Valleys. But generally this range of low mountains or high hills forms a continuous western wall from the northern boundary of the State to the Mexican line. In some places this range of mountains rises in height to from 4,000 to 6,000 feet, and is cut up in every direction with small but fertile valleys, fed by cañons which carry living streams of water, flowing both inland and to the sea.

The other and principal range of mountains is the Sierra Nevadas. This mountain range also extends the full length of the State, north and south, and for the greater part forms its eastern boundary. Its sides are covered with timber and its summits with perpetual snows. Its average height is about 8,500 feet, while its loftiest peaks are Mount Shasta, in the extreme northern end of the State, which rises 14,440 feet above the level of the sea; Lassen Peak, which is 10,557 feet in height; Mount Whitney, which is 15,000 feet in height; and Mount San Bernardino, which stands a solitary sentinel at the extreme southern end of the State, and which is 11,000 feet above the sea-level. Both of these mountain ranges are "storm-gatherers." Along the Coast Range the rain is excessive in winter; and, as a rule, heavy fogs prevail during the summer months.

In the Sierra Nevada range, the rains are also very heavy in winter. In some places, for instance at the base of Mount Shasta, there has fallen as much as 80 inches of water in a single season. The depth of snow in winter on this range of mountains averages from 8 to 20 feet.

Between these two mountain ranges is the great valley of California. In the central and northern part of the State this valley is divided into the valley of the Sacramento and the valley of the San Joaquin. These valleys are in width from 30 to 75 miles, and their combined length is 450 miles. South of these valleys lies another one of surpassing beauty, which extends through the whole length of Los Angeles and San Bernardino Counties, and in which irrigation has recently been largely and most successfully introduced.

II.—The Peculiar Topographical Advantages of California for Irrigation.

The advantages for irrigation will be noted when we observe that nearly every stream heading in the Sierra Nevada Mountains comes from the snow belt, and is supplied by the melting snows, which continue until July or August of each year.

The two great valleys before referred to are almost on a sea-level. Sacramento, which is 89 miles from San Francisco, has an altitude of but 30 feet. Bakersfield, in Kern County, which is distant from San Francisco 314 miles, is 282 feet above sea-level. Redding, in the north, and which is nearly at the head of the valley of the Sacramento, is 299 miles from San Francisco, and has an altitude of 556 feet. Add to this the fact that in these great plains there is very little rolling land, that there is an uniform trend of the surface of the ground from the foot-hills of the Sierra Nevadas west to the Sacramento and San Joaquin Rivers, and we must note the peculiar advantage of this country for irrigation. Perhaps there is no country in the world where so much land can be regularly and profitably irrigated without making any serious changes to the surface of the land as in California. These conditions of things are found to exist in all the great valleys of the State. The two valleys of the Sacramento and the San Joaquin, according to General Alexander, alone cover an area of about 12,000,000 acres of irrigable land. The drainage of this vast country is effected through the Sacramento and San Joaquin Rivers.

III.—The Peculiar Productions of California.

The peculiar productions of California is another reason why irrigation will soon be a great feature in our agriculture. California is situated quite differently from any other Pacific coast State or Territory. Indeed, many of the productions of its soil are peculiar to it. For instance, there are planted in California, according to authentic data, 50,000 acres in orange and lemon trees; all these must be irrigated. Last year there were shipped East for sale 1,850 car-loads of oranges and lemons, *and about 600* car-loads were consumed at home. There are over 20,000 acres of

olive trees planted in California. Most of these are not bearing; some of them are; but enough are in bearing to show that this remarkable fruit grows here with wonderful luxuriance and bears abundantly. The olive thrives nowhere else in the United States. Last year there were produced in this State 3,400 cases of olive oil, and of the very best quality. There are 140,000 acres of land now planted in grape-vines in the State of California; and for the year 1888 there were produced 18,000,000 gallons of wine, 20,500,000 pounds of raisins, and 1,000,000 pounds of dried grapes. These vines are the European varieties, which will not grow where the ground freezes; and they are not successfully cultivated in any other part of the United States. Both our wines and raisins are successfully competing with European productions. There are about 1,000,000 prune trees growing in California, outside of the acreage planted during the winter of 1888–'89. This most-needed fruit is not produced in the United States except on the Pacific coast.

In 1888 California produced 7,000,000 pounds of prunes; and it will be observed that there were imported into the United States for the same year, for consumption in America, over 70,000,000 pounds. In a very short time, California will be able to supply the American market. There are 300,000 fig trees planted in California; and the figs produced here are of the very best quality. The trees grow luxuriantly and thrive well. It must be admitted that it is of infinite importance to our country to encourage the production at home of all these articles which otherwise we would be compelled to import.

In this connection, it may be added that California is a great nut-producing country; the almond grows well and produces well. There are now over 25,000 acres of land planted in almond trees, and this acreage is yearly increasing. In 1888 California produced 180,000 pounds of almonds. The so-called English walnut is also a most valuable California nut, and grows well in nearly all sections of the State where the soil is deep or irrigation possible. No mention is made of the peach, the cherry, the pear, the apricot, the nectarine, the plum, or the apple. All these fruits are grown in California in such abundance that the mention of them seems unnecessary. Add to these fruits the whole berry family, conspicuous among them the strawberry, the blackberry and the raspberry, and we may well observe the unlimited capabilities of this State for fruit culture.

IV.—The Facilities Within the State of California for an Ample Water Supply for Irrigation.

This is the most vital question we have to consider, because, however much irrigation may be needed in this State, if there is not an ample supply of water, it would be more than useless to attempt to carry on any extensive system of irrigation. Owing to the peculiar topographical situation of California, and the fact that for over 900 miles it borders the Pacific Ocean, the great ranges of mountains before referred to and their high altitude, there are a large number of living streams of water flowing from both these ranges of mountains into the valleys below, and which make the water supply most abundant. Two of these streams are navigable rivers, namely, the Sacramento and the San Joaquin—the Sacramento for fully 200 miles and the San Joaquin for about 100 miles. On the extreme southern boundary of the State is the Colorado.

V.—The Names and Character of the Streams that may be Utilized for Irrigation.

The principal rivers which flow into the Sacramento from the east, and whose tributaries reach the highest altitudes in the Sierra Nevada Mountains, are the Feather, Yuba, Bear, American, and Cosumnes Rivers. There are a large number of smaller streams which head in the snow belt of the Sierra Nevada Mountains, and which flow down through the foot-hills across the Sacramento valley and empty into that river. On the west side of the Sacramento Valley there are no large rivers which are tributaries to the Sacramento; but there are a large number of creeks which have a very extensive water-shed and which bear a great amount of water down their courses during the winter. Some of them are perennial streams. Among the larger of these streams flowing from the Coast Range east to the Sacramento are Putah, Cache, Stoney, and Cottonwood Creeks.

The San Joaquin Valley is watered by a number of rivers, all of which have their sources in the great snow belt of the Sierra Nevadas. Chief among these rivers are the Mokelumne, Calaveras, Stanislaus, Merced, Tuolumne, San Joaquin, Kaweah, Kings, and Kern Rivers; all of these flow down into and through the San Joaquin Valley. The combined water-shed of these rivers is 38,500 square miles.

The Mojave River lies south of the San Joaquin Valley, and contains a large amount of water which can be successfully used for irrigation on what is known as the Mo-

jave Desert. The Mojave Desert is a desert only in this sense: there is not rain-fall sufficient to make grass and crops mature; but the soil is rich, the climate genial, and with water almost anything will grow with luxuriance. The capabilities of this river are more fully referred to hereafter. South of this and forming the extreme southern boundary of the State is the Colorado River, which, with the exception of the Columbia, is the largest river on the Pacific coast. It bounds the State of California on the south, and it borders what is known as the Yuma Desert. Wherever water has been applied on this desert the soil has proven productive, instance Indio and other points. Much of this desert is below the level of the river, and some of it below sea-level; it is nearly all susceptible of irrigation, and by bringing water upon it would make this one of the most fertile places in the world. It is estimated that this river will successfully irrigate 1,000,000 acres of land; the most of which that can be thus irrigated is public land and is now of no value.

VI.—The Rain-fall in Different Parts of California.

In considering the amount of water that can be appropriated in California for the purposes of irrigation we must take into view the average amount of rain-fall in the different parts of California, and what portions of the State most need irrigation.

The average annual rain-fall at San Francisco is 23.5 inches. In the foot-hills of much of northern and central California the average rain-fall exceeds 30 inches, while in the great valleys of California it is much less, varying in different localities, but generally increasing as you go north from the lower part of the San Joaquin Valley, where it is about 7 inches, until you reach Shasta at the upper end of the Sacramento Valley, where the annual rain-fall is 35 inches. At San Diego it is 9.2 inches. In California fair crops can be raised from a rain-fall of from 10 to 12 inches, if it comes at the right time, but it rarely comes that way. The trouble is that the annual rain-fall is not uniform, that is, uniform one year with the other. Some years there will be an abundant rain-fall, and another year there will be altogether too light a fall of rain to make good crops.

To illustrate, at Fort Redding one year the rain-fall was 37.4 inches, while the next year it was 15.9 inches. At Sacramento the rain-fall one year was 27.9 inches, while the next year it was but 12 inches. At Fort Tejon one year it was 34.2 inches, while the next year it was 9.8 inches. Clear Lake had one year a rain-fall of 66.7 inches, and the next year it had only 16.2 inches. Visalia one year had 10.3 inches of rain, while the next year it had but 6.7 inches. These are extreme cases and only referred to as an illustration, but it shows that everywhere on the Pacific coast there are years of drought and years of floods. It is true that in the northern and central parts of the State there is rarely a failure of crops; by summer fallowing and careful farming good crops are generally produced. In the coast counties north of Monterey there has never been a failure, though some years have been much better than others. South of Monterey, for the years 1868, 1869, 1870, and 1871, there was a noticeable drouth; stock-raisers were compelled to drive their stock to the mountains or drive it north. In the San Joaquin Valley very little hay and less grain was grown. Even the irrigation now practiced in that great valley would have been of infinite importance. From Tulare to San Diego in 1871 the country was almost barren of verdure, except in favored localities, there was no grass for stock; thousands of sheep, horses, and cattle were lost. It is so long since this occurred that we have almost forgotten it, but still it is an historical fact, and what has been once may be again. It is the part of wisdom to recognize the danger and provide against its recurrence. This could have been avoided if proper systems of irrigation had been introduced. Even now, should a drought occur, the irrigation that is practiced in the central and southern part of the State would largely protect the people against disaster.

VII.—The Area of Lands that can be Successfully Irrigated in California.

According to the survey made by General Alexander, and a report he afterwards submitted to Congress, the area of land in California which may be readily irrigated is about 7,650,000 acres. This does not include the so-called swamp and overflow lands. But should we include these and also include the low foot-hills in this estimate, there would be about 12,000,000 acres of irrigable land in the State of California. Nearly all the foot-hill country of the Sierra Nevada Mountains is not only irrigable, but is wonderfully productive when irrigated. This is now demonstrated in the counties of Placer and Butte, where irrigation is very extensively carried on for the purpose of fruit-raising. Practically only a small portion of this State as compared to its whole area can be irrigated. We should now add 1,000,000 of acres to the above estimate, which would include Mojave and Yuma deserts, Sierra and Honey Lake Valleys, making quite 13,000,000 acres of irrigable land in California.

The area of catchment or water-shed outside of the lands to be irrigated, and which

forms a water-shed of the irrigable lands, is estimated at about 3½ square miles to each square mile of land to be irrigated; and when we bear in mind the fact that this water-shed is most of it in high altitudes, where storms are excessive and snow falls to a great depth and remains for a large part of the year, it will be readily observed that if catchment reservoirs are made in the most favorable localities, and if the running streams are utilized, there is more than ample water in the State of California to irrigate every foot of land which is susceptible of irrigation.

VIII.—Is Irrigation Advantageous?

The advantage of irrigation is twofold: first, the water is applied at a time when it will do the most good, and when the ground is in such a condition that the grain or the fruit trees will get the full benefit of all the water that is run upon the land; and second, where irrigation is practiced there are no droughts. In countries where there is ordinarily an ample rain-fall, the crops often fail by reason of droughts. This arises from the fact that the rain falls in vast quantities, but at unpropitious times, when it does little or no good to the crops.

In California, from about the middle of May until the last of October, we have no rains. During this period grain is harvested.

The use of water is often more valuable for fruit growing than for small grains. We doubt whether the wheat fields of California will ever be irrigated, because fruit is more valuable and the irrigation of orchards is more readily accomplished than the irrigation of the small grains; and because, as a rule, in the great wheat-producing portions of California, irrigation for the purpose of producing one crop of cereals is not necessary. But California is especially a fruit-growing country. Its adaptability to almost all kinds of fruit is peculiar. Perhaps no country in the world is its equal; and in some of the great interior valleys of the State, and also in the foot-hill counties, successful fruit-growing can be made certain only by irrigation. With the orange and lemon, irrigation is a necessity. Where orchards require irrigation, it has been proved that to sustain the trees in their growth and fructification, water need not be put upon the land more than from three to five times during the summer and fall months. The practice is to run water in small ditches between the rows of trees through the orchard about once a month, commencing in June and ending in September. Then immediately after irrigating the ground, by allowing the water to flow through these small ditches, the practice is to put in the cultivator, stir up the ground anew, so that the evaporation will not be rapid, and the ground will not settle down and become hard. The land thus remains friable, and the trees grow with great rapidity.

The orchards and vineyards in the coast counties and in central and northern California have hitherto never been irrigated. Where the size of the grape is an especial and important factor, like in the making of raisins, the irrigation of the vines is advantageous, and especially where the vineyard is planted in very hot and dry situations, like at Fresno and Merced. Up to this time no grapevines nor orchards have been irrigated in any of the counties of Santa Clara, Alameda, Contra Costa, Solano, Sonoma, Marin, or Napa, and the fruit trees and the vines grow there with great luxuriance and produce abundantly; and yet in each of these counties vegetables and the smaller fruits, like strawberries, are now irrigated during some of the summer months.

IX.—The Amount of Water Necessary for Irrigation in California.

There will not be required the same amount of water for successful irrigation in California as is used in India. In India it requires about 1 cubic foot of water running every second to irrigate 200 acres of land to produce cereals. In Granada, Spain, where cereals are produced, 1 cubic foot of water running per second irrigates about 250 acres.

One inch of water running continually irrigates in southern California about 10 acres. Even less than this amount would be required in portions of central and northern California.

X.—The Results of Irrigation in California.

Los Angeles and San Bernardino Counties are conspicuous illustrations of what irrigation can accomplish. Nothing can picture the change which has there been made by means of irrigation. A great plain, which once looked like a desert, is now covered with beautiful homes, surrounded with orange orchards and vineyards, dotted with towns and cities, which have grown up everywhere as if by magic. The population has more than quadrupled in a single decade. Lands which sold ten years ago at from $5 to $25 per acre now sell at from $100 to $1,000 per acre, and these prices

seem to be fixed from what the lands actually produce. Nor is this condition of things peculiar only to southern California. In Placer County water has for some years been used for the irrigation of orchards and vineyards there planted. It is impossible to describe the change thus created. Orchards of every variety of fruits, from the orange and lemon to the apple, and vineyards of every rare variety of grape, and nuts of all known varieties grown in semi-tropical climates, and the fig and the olive, all seem to flourish in the foot-hills of Placer County; nor does the result in Placer County seem to be peculiar to that locality, for everywhere in the foot-hills of the Sierra Nevadas, where irrigation has been introduced, the result has been equally surprising.

The foot-hill country about Oroville, in the county of Butte, where water has been introduced, is no less conspicuous for its luxuriant tree-growth. Within the last four years 1,500 acres of orange orchards have been planted, and these trees seem to be thriving well. The oranges are rich in color, luscious in taste, and attractive as to size. This is mentioned only to show the effect of irrigation upon both the foot-hill and valley lands of the State of California.

More marvelous still is that section of country lying about half-way between the extreme northern and southern part of the State. We refer to Fresno. The writer of this has seen Fresno a veritable desert; it is now a garden of surpassing luxuriance and great beauty. Within the past few years a town has been built there, which has a population of over 10,000; the surrounding country is cultivated in everything the farm can produce. Indeed, Fresno County is to-day the great raisin-growing center of the State, and nearly every variety of fruit grows abundantly. There a beautiful orchard stands side by side with an alfalfa or grain field. Homes are literally hid away by the remarkable ornamental tree-growth which irrigation has caused. Ten years ago the lands of Fresno sold at from $3 to $20 per acre; now the same land with water on it sells at from $75 to $750 per acre. This is all due to irrigation. Kern County is another conspicuous landmark on the road to successful irrigation; more than 80,000 acres of land is being irrigated in that county. The production is generally alfalfa.

Everywhere in California during the summer months garden vegetables are raised by irrigation. In the fall, winter, and spring months in most parts of the State they require no irrigation, except such as they get from the natural rain-fall. So with strawberries; this fruit is universally irrigated. In Santa Clara County alone it is claimed there are 1,500 acres of land cultivated in berries, all of which are irrigated; and that there are over 500 acres cultivated in garden vegetables, which are also irrigated. Even in northern counties like Napa, where the annual rain-fall is almost three times as great as in some parts of southern California, strawberries, other small berries, and garden vegetables during the summer months are universally irrigated.

Without wishing to select any portion of the State to give it especial prominence in this report, yet it would seem both wise and necessary that the most conspicuous object lessons found in California, in the way of irrigation, should be particularly and exhaustively referred to. We do this for the purpose of illustrating what irrigation has done in the past, what it is doing now, and what its possibilities for the future are. Your committee has therefore selected, as special examples for this purpose, some portions of southern California and the San Joaquin Valley, where irrigation has been carried on for a great many years, and where it is now largely and most successfully adopted. And as this report is intended, in so far as we are able to do so, to place facts before the people both of our own State and the people of other sections of the country, as well as the committee of Congress which is soon to visit us, we have ventured to select the most marked and illustrious examples within the range of our knowledge to give more forcible expression to what is known upon this most interesting subject. Los Angeles and San Bernardino Counties are most conspicuous illustrations of what is being done in irrigation; and we therefore venture to present the following carefully-prepared yet conservative reports from those two counties, and also an equally interesting and conservative report from a part of the San Joaquin Valley.

XI.—Necessity for Irrigation in Portions of northern California.

The Sacramento Valley contains no lands strictly arid; but most of that great valley would be benefited by irrigation, and as to which the Government might well lend its assistance, at least to the extent of determining the water-storage supply or other means of irrigation.

Large areas of plain or bench lands, lying above the bottom lands of the river, are to be found in Shasta, Tehama, Butte, Colusa, and other Counties. They are all within reach of the water flowing down the Sacramento River and its lateral tributaries. Most of the streams emptying into the Sacramento from the Coast Range sink and disappear during the summer not far below where they debouch from the mountains into the open country; but at their sources there are large quantities of water

and extended areas of water-sheds. It is believed that excellent facilities for water storage can be found on all these streams.

The creeks flowing from the Sierras, on the contrary, are generally constant and unfailing, though diminishing in quantity through the summer.

In Lassen and Modoc Counties, especially in Lassen, will be found an extended field of usefulness for Government work. There are few places to be found in all the regions to be examined by the Senate committee, covering an area of excellent lands, worthless without irrigation and invaluable with it, where all conditions are so favorable for immediate results as in Lassen County. Nature has built a reservoir in Lassen County called Eagle Lake, covering an area of 35,000 acres, and of great depth, in many places over 1,500 feet. A tunnel 7,000 feet long would tap the lake 12 feet below the surface; and, by an additional open tunnel of like length, the lake could be tapped 20 feet below the surface. It has a water shed of over 400,000 acres in the regions of our heaviest rains and snow-fall. Its elevation is 5,115 feet.

Willow Creek was probably once its outlet, and through subterranean passages now receives its first escaping waters. This creek runs through Willow Creek Valley today and into Honey Lake Valley.

The Susan River rises west of Eagle Lake, and has a water-shed separate from that of Eagle Lake, and about as large. It flows into Honey Lake Valley; very fine storage sites are to be found near the source of this stream, consisting of lakes and extended flats.

The irrigable lands of Lassen County, lying about 1,000 feet below these sources of water, are not far from 500,000 acres; and east of these lands, in the State of Nevada, is an area of like extent, which would form a part of this scheme of irrigation. The lands are rich, sandy loam, productive with water, but comparatively useless without. The climate of Honey Lake Valley is most delightful, being free from excessive heat and not subject to very low temperatures. Hardy fruits excel here, and with irrigation alfalfa grows luxuriantly, producing three crops in a season. To many Eastern people the climate would be preferred to the lower valleys. Here there is a region of nearly or quite 1,000,000 acres of public lands that can not now be settled upon, but are nevertheless capable of sustaining a large population.

A rough calculation shows that in Eagle Lake there is already stored enough water to irrigate 500,000 acres of land; and at the head of Susan River comparatively cheap reservoir sites are available to store water sufficient for a half million acres more.

North of this region lies Madelin Plains, a large area of good lands if irrigated.

In Modoc County like areas are lying idle and useless, yet are capable of high cultivation and of sustaining a large population.

These lands are all within reach of water, but the work of survey is expensive, and there being no way by which capital can acquire the land, there is no probability of any relief ever coming to these regions except by Governmental interposition.

If it is true that there are 1,000,000 acres of land which may be irrigated at an expense of $1,000,000, and that these lands lie upon the great interior desert plain of our continent, by what possible scheme could the Government hope that enough people would go there in advance and expend the money which they must do before the land is available? The Government must either do the work, or it must give to capital something more than the vague expectation that people will buy the water.

As a first step, the surveys of irrigable land and sites of reservoirs will prove beneficial. The duties of the Senate committee must reach beyond the mere demonstration that land and water may be brought together. It must show how this may be done and ought to be done by the General Government.

XII.—Owens Valley, in Inyo County.

Inyo County, Cal., is especially adapted to irrigation, particularly that part of it known as Owens Valley. From Olancha to the head of Round Valley is 100 miles; the whole of this distance, a strip of country from 4 to 6 miles in width, is susceptible of irrigation. There are from 300,000 to 400,000 acres of land of unsurpassed fertility which are utterly worthless without the use of water. It is claimed by experienced engineers that the Owens River carries on an average, and during the summer months, water enough to place at least a surface depth of 15 inches upon an area of 300,000 acres of land, and this without preparing catchment reservoirs. A large portion of this country is still a part of the public doman. Less than 12,000 acres of land are now cultivated in Owens Valley.

XIII.—Irrigation in Los Angeles and Orange Counties.

In considering the subject of irrigation in Los Angeles and Orange Counties, we find it a complicated one. The number of ditches run into the hundreds, and the number of systems and *subsystems, companies* and associations, to several scores. The

length of the ditches is hundreds of miles, irrigating many varieties of soil and crops. The area of actually-irrigated lands in the two counties is in the vicinity of 150,000 acres.

The sources of the irrigating water supply of these counties are the rivers Los Angeles and San Gabriel, in Los Angeles County, the lower part of the Santa Ana in Orange County (the upper part being in San Bernardino County), many creeks and small streams whose flow is of short duration, springs and springy lands (called cienegas), and many hundreds of artesian wells. The rivers, except the Los Angeles, rise in the high mountains and are practically perennial. It is true their waters disappear in their sands during most of the dry season soon after debouching from the mountains, but they reappear at intervals all the way to the sea, and can be taken out at almost any point along their channels by simply running ditches into them. The water supply in the rivers alone is sufficient to irrigate all the land of the counties to which water could be advantageously applied, if properly stored and distributed. The volume of the streams in winter is enormous—utterly beyond computation, and but a small portion of it would need to be saved for use in the dry season. The average summer flow of the San Gabriel River is about 10,000 inches; that of the Los Angeles River is 3,750 inches, and that of the Lower Santa Ana 4,000 inches. This estimate is of surface flow only. During the usual three months of the irrigating season the water is all appropriated; it is not all utilized, however, as much is wasted both by seepage and evaporation in the open, porous-earth ditches in which it flows, and much is allowed to run to waste. The streams whose waters rarely show outside the mouths of their gorges, except under the influence of considerable rain-fall are capable of furnishing a great quantity of water for storage. In many instances they are the only source of supply for the higher mesa and foot-hill lands, and are well worth the expenses of storing; for some of these lands yield fruits in the greatest perfection, and they are unquestionably the most healthful and delightful dwelling places. A great deal of water is obtained from springs and springy lands. These lands are found all the way from the mountains to the sea; but the greater number of those used for irrigation are situated on the higher plains or at the base of the main range. The most notable instances of these sources of supply are the springs and marshy lands of Pomona on the eastern border of Los Angeles County, the springs of Santa Anita and San Gabriel, the marsh lands of the Rio Honda and Paso de Bartola near the center, and those at the head of the Los Angeles River, on the San Bernardino Plains near the west line. They furnish many hundred inches of water, and are among the most reliable and valuable of water rights.

THE ARTESIAN WELLS OF THE TWO COUNTIES AFFORD A VERY LARGE AMOUNT OF WATER.

Pomona orchards are largely supplied by them. So are those of the Santa Anita and San Gabriel Valleys; while the lower coast plain has hundreds of such wells irrigating fields of alfalfa, vegetables, and most varieties of fruit. These wells have an average bore of six inches, depth of 150 feet, and a flow of two inches. Not more than one-third of them, however, are flowing—that is, about 1,500.

There is promise of the development of great quantities of water by the construction of submerged dams in the gravel-filled channels of the streams. There are several such dams in the county; but I have been unable to get statistics with regard to but one. That was built in the Pacorima, a stream in the northeast corner of the San Fernando basin. The owner claims it to be the largest in the world; it is 600 feet long, with an average depth of 60 feet. It consists of a wall 6 feet thick, of granite bowlders and Portland cement, built up from bed-rock and filled against, back and front, with sand and gravel. It developed a subterraneous stream 40 feet wide and 16 feet deep. Unfortunately, through some fault in construction, the dam was unable to retain the waters but a short time after its completion last year.

SUB-IRRIGATING SYSTEMS HAVE BEEN CONSTRUCTED.

They consist of cement pipe of the smaller dimensions laid at a depth of the deepest plowing. The pipe cannot endure much pressure, and requires to be laid nearly level. The ends of the pipes are perforated to admit a flow of the water into the earth about the roots of the trees. By a patented process, a continuous pipe is laid at the required depth. Subirrigation requires much less water and no surface work except cultivation. It discourages the growth of weeds and prevents the hardening of the ground about the trees. As at present applied, however, it does not uniformly moisten the earth inclosing the roots, and is not regarded as a complete success.

THE FACILITIES FOR STORAGE.

There is a difference of opinion among engineers. Some think there are many basins and cañons in the mountains which are adapted to the purpose, and others think these, on most streams, are wanting. Most, however, agree that the bench lands furnish abundant opportunities for the construction of reservoirs. The storage of water in the cañons may be effected by throwing dams at favorable places across the mouths of such cañons or basins as have the least wash, and afford the largest capacity and possibility of leading the water into them from adjacent streams.

The reservoirs on the bench lands may be constructed by excavating, and at much less expense than those in the cañons, and be of much safer character. They would not, however, be able to deliver their waters at so high an elevation, and would leave considerable land to be supplied from other sources. The filling of such reservoirs is effected by piping, fluming, or ditching from the upper waters of the streams. There are a number of reservoirs of both kinds, finished and in process of construction, of capacity varying from a few thousand to a billion gallons. One on Mormon Creek, in the rim of the San Fernando basin, is of more than the latter capacity.

Suffice it to say there is no lack of facilities for the storage of water with safety and profit. The first expense, however, is very great; and private enterprise is not ready to undertake it on a large scale except in the most favorable localities. The waters of the San Gabriel River brought out upon the higher hill-lands of the Ayusa or Duarte would suffice to irrigate all the great valley below, the coast plain beyond, and the intervening range of hills to their very tops. The waters of Millard Cañon and the Arroyo Seco, stored in the vicinity of the Giddings ranch, or the lands of the John Brown's sons, or other available places, could be made to flow over the San Rafael hills and those in and adjoining east Los Angeles. So with the San Dimas and the streams of Santa Anita, Eaton, Tejunga, Pacorima, San Fernando, Mormon Creek, Verdugo, and Santiago, whose flow in the aggregate is enough to supply all the lands between them and the ocean many times over. Also over the range in the hitherto regarded irredeemable desert of the Mojave, where most of the land still belongs to the Government, and the soil is as rich as lies under the sun, whole townships of the finest raisin grape, fig, and deciduous fruit land may be irrigated by the waters of the Mojave, Big and Little Rock Creeks, Oak Creek, and some others—most of which show surface water only in the rainy season—if those waters are husbanded, as there are abundant facilities for doing. And in the Newhall region, the Santa Clara, the San Francisquito, and the Castaic may be made to greatly increase the productiveness of the valley and the wealth of the county.

The number of acres of good land which require irrigation are, south of the mountains, according to the State engineer's estimate, 460,900. North of the Sierra Madre range, Los Angeles County shares with Kern and San Bernardino in the great Mojave desert, so called. This desolate region contains many thousand square miles. In these three counties one-half of this is probably arid beyond redemption; one-half of the remainder is too rough and mountainous to be valuable for cultivation, but the remainder is mostly highly fertile soil, lying favorably for the application of water. Of this vast territory, Los Angeles County possesses 250,000 acres which can be made to comfortably sustain a population of 100,000 people.

It is stated that the lowest summer flow of the Mojave River is about 5,000 inches. The average flow for six months in the year, the winter and spring months, is from 20,000 to 30,000 inches, during May, June, and July more than 10,000, and for the rest of the season more than 5,000 inches. Of this the Hesperia Land and Water Company has filed a claim of 5,000 inches. The Hesperia Company irrigates about 300 acres of land, and is flooding 15,000 acres for the purpose of preparing it for cultivation with the use of less water than it would otherwise require. The remainder, properly cared for, will redeem half a million acres of now absolute desert and make it as rich and blooming as the plains of Babylon thirty centuries ago.

SITES FOR STORAGE RESERVOIRS ARE ABUNDANT.

The land is mostly Government land, and the profits thereon would pay for enormous and elaborate works. Big and Little Rock Creeks, which debouch upon the desert plain at higher elevation, west of the Mojave River, are wholly within Los Angeles County. Their flow in winter is thousands of inches, and in summer is sufficient, as at present handled, to irrigate several hundred acres. Facilities for storage on these creeks are as abundant as on the Mojave. The land below is still owned, for the most part, by the Government. The universal testimony is that it is as fertile as the best. It is covered with grass and flowers during several months of the year, and is capable, under irrigation, of producing the most luxuriant and profitable crops. Artesian-well boring has proved successful in places on the desert, but the expense is of course greater than elsewhere. The region is one of the most

healthful on the globe. Its hot, dry atmosphere is found congenial to many people. It is especially adapted to the production of certain crops, as the fig and raisin grape. It produces in some places as fine wheat as is raised anywhere, but to become habitable for any more than a few scattered families or small communities, it must have water to save its crops in summer. We have an engineer's report with regard to Little Rock Creek. He finds ample winter flow to furnish irrigation water, if stored, for 270,000 acres, allowing 1 inch to 5 acres. He allows for 30 inches of evaporation, and finds sites and gives estimates for two reservoirs, the larger one having a capacity of 644,000,000 gallons, and to cost $125,000. There is reported from the same locality 800 acres to which water is applied; 200,000 acres irrigable—one-half of which belongs to the Government; 14 miles of ditches. Value of irrigable land, $50 per acre; non-irrigable land, $1.15 per acre; the number of artesian wells in the region, seven, with an average depth of 340 feet and average flow of 12 inches. The counties of Los Angeles and Orange have an area of 4,812 square miles or 3,079,680 acres. Their population is fully 150,000 souls. Without irrigation not one-quarter of this number would be living there; and "this in spite of the fact that those two counties produce more than one-half of the corn of the State almost altogether without irrigation; that there are nearly 90,000 acres of good land that require no irrigation."

The land now irrigated is about 150,000 acres, and this is the basis of maintenance of 113,000 people. Theoretically, no increase of this population is wanted without a corresponding increase of irrigated lands. Factories and mineral developments, travel and transportation by sea and land, and the healthfulness and delightfulness of the climate, would add to the population; but the cost of living would be increased in proportion to growth, the homes of the poor would no longer be those of people who control their own destinies; and this would become a rich man's paradise—a thing not to be desired.

FORMER AND PRESENT POPULATION.

Ten years ago the population of the counties was little over 30,000. Fifteen years ago the land on which Pasadena now stands was held at $7 per acre; in seven years it was valued and sold in large quantities at from $500 to $1,000 per acre. This was for orchards—not city lots—orchards made possible only by a supply of moisture for the roots of the trees during the long arid season of the year. So with the whole of the great foot-hill region along the base of the Sierra Madre range from Tejunga and Crescenda Cañada on the west through Altadena, Sierra Madre, Lamanda Park, Santa Anita, Monrovia, Duarte, Ayusa, Glendora, Alosta, San Dimas, Lordsburg, Cucamonga, Rialto, Redlands, and over the San Gorgonio Pass into the desert at Indio, and again at Riverside and Arlington, and places too numerous to mention. The growth has been proportionate to the extent to which irrigation has been carried. The region mentioned was almost worthless even for grazing purposes, and was as incapable of sustaining a population as the Mojave desert itself. Now visit it and you will find it the most charming region and the most valuable land in all California, or in the United States for that matter.

IRRIGATING CONDUITS FOR THE WATER OBTAINED FROM THE MOUNTAINS

In every direction, either above or below the surface like a spider's web, the ditches, flumes, and pipes are leading the life-giving fluid. It is for the most part above the region of wells, so that the water for all purposes has to be brought in. Where no provision has been made for supplying a locality from running streams, a reservoir is made, or other methods adopted. The mountains are bored and tunneled for seepage and spring water; wet places in the cañons and gulches are underdrained; springs are cleaned out, and reservoirs of various sizes constructed to increase and store the flow. Pipes are laid for long distances into the cañons to bring the trickling streams from their hiding places to the light and usefulness. Ingenuity and experience as well as capital are required to find many of these waters. Much money has been expended to little purpose in such work; but a great many inches of flow have been obtained in this way—much more than enough to compensate for the outlay in this direction.

In the ranges of hills between the mountains and ocean, water has been and is being developed in the same way; but the difference in the soil and the moisture borne on the ocean breeze renders less water necessary, and the same enterprise in obtaining it has not been displayed. The Whittier Colony is a notable exception to this rule as to enterprise, though not as to need of irrigation. There are probably now 1,500 miles of irrigating conduits in those two counties.

The character of these conduits is continually changing. Flumes are being substituted for catch-ditches, and cement or iron pipes for both. There are now quite *400 miles of* underground conduits. Every system and character of irrigation is here

exemplified—from the ancient methods of the Indians and Mexicans to the most improved modern systems, including subirrigation, flooding the lands, channels and basins, slow streams and deep-wetting, quick, full, and frequent flow, the use of 1 inch to 10 acres, and of an inch to 1 acre (the inch flow giving 12,560 gallons per day, equivalent to 4½ inches rain-fall in the one hundred days of the irrigating season), and so on, *ad infinitum*. All phases of the subject may be found treated here.

In most instances the value of the water-right and the appurtenances is divided into shares, and then are owned by each irrigator in proportion to the number of acres he wishes to irrigate. He pays his share of the expenses, and takes his share of the water in his turn, which is settled by agreement at the beginning of the irrigating season. The amount of water applied to irrigation depends upon contingencies. The water is measured by inches or heads, 1 inch being the amount that will flow through an inch-square orifice under 4-inch pressure. The head nominally is 100 inches; the run is for any number of hours according to agreement, usually from twelve to twenty-four. The irrigating season is ordinarily about three months, July, August, and September. A man is employed to turn the water to each irrigator as his time comes; this man is called a "Zanjero," as the ditch in Spanish is called a "Zanja." He receives from $1 to $1.50 per day for the season. The cost per acre is from 30 cents to $1.50 for the year, which covers all expenses. Many of the open ditches are injured during the rainy season, and a great deal of ditch repairing is required at the beginning of every dry season. The pipe system escapes this and other drawbacks which attend the old, crude methods of the first settlers.

The average rain-fall of the region is about 12 inches, running from a light precipitation near the coast to a copious one in the mountains and foot-hills, though different parts of both localities are more or less differently farmed. There have been no droughts in ten years, but droughts can have no such effect upon the region as formerly. The people know so well how to use and husband the moisture that no material damage could be done to the country by a lack of rain-fall that did not continue for several years. We have no general failure of crops, and every year makes assurance doubly sure that it can never occur again.

The value of land in this section lies in the water. In the San Gabriel Valley water has actually been sold at the price of $15,000 per inch, which price at 1 inch to 10 acres would be $1,500 per acre. The average value of the product of unirrigated land is not more than one-tenth that of irrigated.

The difference in the variety of the crops possible to raise, and in the capacity of the two kinds of land to sustain population, is quite as great. The improvement in the character of the population is as marked as in numbers; intelligence and energy distinguish the new occupants of this country from the old. With regard to the practical knowledge of irrigation, there is probably no field in the world where it is more exhaustive than in these two counties. It has been applied here for more than a hundred years, and has gradually grown from the simple methods of Spanish-American settlers to the most elaborate of modern systems.

XIV.—Irrigation in San Bernardino County—Storage Reservoirs as Aids to Irrigating Systems.

The great value of storage reservoirs is just beginning to be appreciated in southern California since the actual use of water from Bear Valley reservoir has commenced, in connection with the natural flow of the Santa Ana River.

The supply of water from a stream is just the reverse to the demands made upon it for irrigating purposes. The natural stream is large in January, diminishes in size till July or August, and then increases in volume till January again.

The use of water for irrigating purposes is least in January, and increases gradually until August, and then diminishes again till January.

The value of a stream for irrigating purposes is measured by the duty its water will do at that season of the year when the most water is required, or when the stream will irrigate the smallest amount of land.

All surplus water at other seasons of the year is of no value for irrigation purposes, except as it can be stored for future use.

Suppose we have a stream of water that carries 1,000 inches under a 4-inch pressure, or 20 cubic feet of water per second, at the driest time of the season—say August—of each year. This stream of water is sufficient in San Bernardino County to irrigate 5,000 acres of land in good shape, or, if conditions are favorable, perhaps 10,000 acres. The water in the stream is not all called into use until the months of July and August, and then at times every drop must be utilized. During June and September there is enough water for 20,000 acres, and during the balance of the year there is enough to irrigate from 25,000 to 50,000 acres or more. These are rough estimates, but they are practically correct, although in different seasons the irrigating capacity of the stream will differ.

Now the theory of the people should be to furnish an independent supply of water that could be turned into this irrigation system at a time when it will do the most good.

Suppose that it was desirable to make this stream irrigate 50,000 acres of land where it now irrigates but 5,000 acres.

To do this work would require 9,000 inches additional in July and August, perhaps 5,000 inches additional in June and September, 2,000 inches additional in May and October; and, as a rule, the stream would take care of the entire tract during the remainder of the year.

Here we find that a stream of water equal to 30,000 inches for one month would irrigate 40,000 acres of land, whereas if it were not used in connection with a natural stream it would not irrigate one-quarter that amount. This would require a reservoir 1 mile square and about an average of 55 feet deep.

Bear Valley reservoir, in San Bernardino County, was started as an experiment, but it has proved itself more valuable than its founders had hoped it would be, and steps are being taken to make it still more valuable by increasing its capacity and constructing a dam to a height of 120 feet, whereas its present height is but 50 feet. This reservoir is located 6,000 feet above the sea-level, where the evaporation is very light, and where the water can be stored in its natural purity.

This reservoir commands the entire San Bernardino Valley on both sides of the Santa Ana River from the mountains to the chain of hills which separate the interior valley from the coast valleys of Orange County. This great interior valley extends from Pomona on the west to San Gorgonio Pass on the east, a distance of 50 miles, and from the Sierra Madre Mountains on the north to the Temescal Mountains on the south, a maximum width of 25 miles.

In this great valley is to be found Pomona, watered by the waters of San Antonio Creek and artesian wells; Chino with its vast extent of moist land, and its large tract of dry land irrigated by artesian water from the Pomona artesian belt; Ontario irrigated from San Antonio Cañon, and by waters flowing from a tunnel run for half a mile beneath the bed of the San Antonio Creek; Cucamonga irrigated by the waters of Cucamonga Creek and by artesian wells and by tunnels run beneath large cienegas; Etiwanda irrigated by waters from Etiwanda and other cañons, and Rialto watered by Lytle Creek. These form a group of thrifty settlements extending along the foot of the mountains to the west of San Bernardino.

The city of San Bernardino is located in the midst of a large tract of artesian land that that is naturally moist, and that covers over 20 square miles of territory.

Through this artesian belt flows the Santa Ana River, which in summer-time gets its entire available water supply from its tributaries, which take their rise in this moist-land section; for at the mouth of the cañon, where the river debouches from the mountains, the entire stream is taken from the river-bed, one-half to irrigate Highlands on the north, and the other half to irrigate Lugonia, Redlands, and Old San Bernardino on the south.

The mouth of the Santa Ana Cañon, where these waters are taken out, is about 2,000 feet above sea level.

Farther down the stream and on the southeast bank is to be found the Riverside settlement. This valley, or section of the valley, comprises 12,000 acres under the Riverside system of canals, which take their water from the Santa Ana River and from its principal tributary, Warm Creek. Above this lies the Gage tract of 10,000 acres, irrigated from the Gage canals, which take their waters mostly from artesian wells; and still above this is another strip of 5,000 acres, which is being irrigated from a system of wells located to the northeast of San Bernardino, and piped to the land, a distance of about 10 miles. This gives the Riverside section a tract of country amounting to about 27,000 acres.

Still farther down the river, and on the same side, is located South Riverside, with about 8,000 acres on the south side of Temescal wash, and about 3,000 acres on the north side of the wash, the latter tract being known as Auburndale. These tracts are being irrigated by waters from cienegas and artesian wells located in the Temescal Valley, about 6 miles above the upper edge of the tract. These waters are conveyed to the tract in a 32-inch cement pipe, and then distributed in smaller iron and cement pipes.

On the opposite side of the river from Riverside is situated the Jurupa tract of land, comprising about 25,000 acres, over half of which is moist or semi-moist land, while the other half is fine orange land, and is to be irrigated by water developed in the lowlands along the Santa Ana River, and by water from the artesian belt. All ready the canal, with a capacity of 5,000 inches, is nearly completed to the lands, at a cost of $150,000; and about 1,000 inches of water are flowing therein—more water than is yet needed by the 3,000 acres now under the completed portion of the canal.

This review completes the principal irrigated sections of this great valley.

There is probably enough water in sight, to-day, to irrigate one-half of the irrigable, arable land in the San Bernardino Valley; and storage reservoirs must be depended upon largely to complete the work.

To the south and east of this valley is another large valley, the San Jacinto, which is about 25 miles long by 15 miles wide. This is a large body of fine land, at present mostly sparsely settled, principally because of lack of water. In the upper end of the valley is situated the town of San Jacinto, in quite an extensive artesian belt. The San Jacinto River furnishes some water for irrigation purposes, but the supply is limited. Upon the headwaters of this stream, which heads in the mountains bearing the same name, is a small mountain valley very similar to that of Bear Valley, where the Hemet Valley Reservoir Company has taken steps to construct a reservoir that will do for San Jacinto what the Bear Valley reservoir is doing for the San Bernardino Valley. It is a feasible project, however, to irrigate this entire valley from the waters of Bear Valley reservoir, by means of a pipe, 10, or, perhaps, 20 miles long

There are other reservoir sites in the mountain valleys that can yet be utilized.

There is one located on the north side of the mountains on a branch of the Mojave River high up in the mountains, so that from the mouth of the reservoir a short tunnel through the mountains would deliver the water out into the San Bernardino Valley, where it will be of greater value than if used on the desert side. This reservoir when constructed will hold water enough to irrigate several thousand acres of land, and can be made to supplement the waters of Lytle Creek to good advantage. The cost of this reservoir and tunnel will not exceed $35,000; and as much more money would probably deliver the water to the Lytle Creek Water Company, which irrigates the lands about Rialto.

The dry mesa lands of the San Bernardino Valley have no value until they are irrigated, except a speculative value. If a water-right can be bought for $100 an acre, and the irrigated land sold for $200 an acre, these facts have an influence on the speculative value of the dry land.

VALUE OF IRRIGATED LAND.

Choice land for orange culture is selling to-day at from $125 per acre—extremely low—to $200, $250, and even $400 and $500 per acre, according to location, and circumstances surrounding the owners. Without the water the value is nominal.

A cubic foot of water per second is equal to 50 inches of water under a 4-inch pressure; and 1 inch of water is a good water-right for 5 acres of land, and a fair water-right for 10 acres under favorable circumstances. Water is being developed in various ways.

Large amounts of water are being obtained from artesian wells; and this supply, when obtained, appears to be permanent.

Tunnels are frequently run under beds of creeks and under cienegas; and the results have been very satisfactory. In one instance, at Cucamonga, a tunnel was run under a cienega covering 5 acres, and furnishing but 6 inches of water. This tunnel was 500 feet in length, and a branch tunnel the same length was also run. The two tunnels dried up the surface of the cienegas entirely, and furnished a permanent flow of 196 inches, or 4 cubic feet per second.

Storage reservoirs will become a necessity in the irrigation of the arid lands of America, as they are in irrigating the plains of India; and the Government should take a hand in reclaiming these lands, either directly or by advancing the funds to do the work, to be repaid back after the lands are made productive.

Riverside has 3,000 acres of orange orchards, a portion of which is yielding good crops, a portion is yielding partial crops, and a portion is not in bearing at all. These 3,000 acres this year produced 1,000 car-loads of oranges and lemons, worth on the track an average of $750 a car, or $750,000—about $250 an acre. This is not picking out sample orchards, but averaging all the orchards, whether in bearing or not.

Budded trees yield the third year in orchard $1.50 per tree; the fourth year, $3 per tree; the fifth year, $4 to $5 per tree—from $300 to $375 per acre; eight-year old buds, $10 per tree; and nine-year old buds, $15 per tree, or $1,125 per acre. From six to seven boxes to the tree have been received from fifteen-year old seedling trees; and this gives a net income of $1,225 an acre, counting the first but $1 a box on the tree.

These are some of the reasons why choice lands have sold at from $250 to $800 and $1,000 an acre in good locations, and why water has been developed and put upon land at a cost of $150 and $200 an acre for the water-right alone. During the past two years there has been an advance in the price of bearing orange orchards, as the trees have grown in size and have increased the amount and value of their crops.

There is no place in the United States where the benefits of irrigation are more fully illustrated than they are in the San Bernardino Valley.

XV.—In San Diego County Irrigation is a Necessity.

The streams of that county, except the Colorado, which flows along its southern boundary, are not large, nor is the water supply, without using catchment reservoirs, equal to the *demand*. *Within the past* few years, much attention has been given to

the matter of irrigation in this locality. One great reservoir has been constructed, and others have been surveyed. And thus it will be observed that provisions are being made to store the waste waters of winter for practical uses in summer. This has already given special activity to horticultural and agricultural interests in this county, the possibilities of which have not hitherto been known or appreciated even by those who have lived there many years.

XVI.—THE AMOUNT OF LAND NOW IRRIGATED IN THE SAN JOAQUIN VALLEY.

In Fresno County there are about 100,000 acres of land now irrigated. This estimate is made by Mr. George Manuel, a well-known civil engineer; but he adds:

"It is somewhat difficult to draw the line between irrigated and unirrigated lands, for the reason that the effects of irrigation by filling up the country affect and render fertile to a great extent lands lying contiguous to irrigated lands, but not themselves subjected to irrigation by the usual methods of application. Of this latter class of lands," says he, "there are about 200,000 acres."

Thus it will be seen that the 200,000 acres are an area double in extent of that which is actually irrigated, and is reaping the benefits without being subjected to any of the burdens of irrigation. Irrigation in Fresno County has heretofore been carried on wholly by the private canal system. It is a voluntary matter by this plan with each land-owner whether or not he will contribute anything towards the expense incident to the irrigation of lands. His lands may be surrounded by irrigated lands, and thus in a short time they become sufficiently irrigated by percolation; but he may and does decline to buy water where he can get it by absorption without. By the district plan this iniquity is overcome; and every man who owns land that will be benefited is compelled to contribute his portion of the expense incident to the system, and gets in return all the water he may require.

The following is the estimate made by Mr. Manuel of the amount of lands in Fresno County which is now not irrigated, but which is irrigable:

	Acres.
(1) In Madera irrigation district, about	300,000
(2) Under Chowchilla canal, excluding about 5,000 acres already irrigated	60,000
(3) Land lying above or east of Madera district, but which can be irrigated by a branch of the main canal of said district (in Fresno County)	87,600
(4) Lands lying above water in main canal of Madera district, but which is susceptible of irrigation by a system of storage reservoirs	38,400
(5) Land lying between San Joaquin and Kings Rivers, excluding about 60,000 acres already irrigated, and which can be irrigated by existing works or their extensions	684,960
(6) Land lying above or east of Enterprise canal, but which can be covered by storage reservoirs or branch canal taken out high up in the mountains	40,000
(7) On west side of Fresno Slough, below Hall survey in Fresno County, which can be covered with extensive irrigation works	113,000
(8) In Sunset irrigation district above Hall survey, proposed to be irrigated by a canal having levees 35 feet high at highest point, and about 15 miles long, and which lie above Hall survey	190,000
(9) Between the 240 and 300 feet contour line on State engineer's map, which can be irrigated by canal taken from Kern River, or by water pumped by water power as proposed by Sunset district in Fresno County	190,000
(10) Land lying above the 300 feet grade line in Fresno County on west side, which can only be irrigated by storage reservoirs on the streams flowing from the Coast Range	293,000
Total	1,996,960

All of the above lands, with the exception of about 200,000 acres lying near and affected by the present irrigation, and possibly 50,000 acres lying near the foot of the Sierras on the east side, are practically useless without irrigation.

Instancing the benefits of irrigation in Fresno County, Mr. Manuel states: As examples of the benefits of irrigation, the following is from the assessor's records of Fresno County, for T. 14 S., R. 20 E., showing the former and present assessed value of property:

In 1870.—Sections 1 to 35 assessed to W. S. Chapman at $1.01 per acre; section 36, at $1.13 per acre.

In 1880.—Bank of California tract, 12 sections at $4 per acre.

Bank of California tract, 240 acres at $5 per acre.

C. A. Towne, section 2 (adjoining Fresno City) at $5 per acre.

C. H. Hoffman, section 12 (near Fresno City) at $5 per acre.

E. Jansen, 6 sections (near Fresno City) at $4 per acre.

In 1888.—A. T. Covell, in Washington Colony, 5 miles from Fresno, 60 acres at $150 per acre.

Sections 1 and 2, and 11 and 12, $250 to $350 per acre—$250 about average for unimproved land.

Sections 30 to 31, unimproved, at $40 per acre.

Sections 6–7 at $100 per acre.

Section 19 at $75 per acre.

Sections 5–8 at $125 and $200 per acre (unimproved and from one-half to 1 mile from city of Fresno).

Sections 17, 18, and 19 average $85 per acre.

Sections 23, 24, 25, and 26 at $75 per acre.

The above valuations from the assessment rolls of Fresno County teach an instructive lesson.

Ten years ago, when the effects of irrigation in Fresno County had been but little felt, the present city of Fresno was but a struggling village of probably from 1,200 to 1,500 souls. Now it is a bustling city of 10,000 inhabitants.

In Tulare County much progress has been made in the work of irrigation. The one criticism to be made on the work in that section is that it is fragmentary and lacks uniformity and systematic methods. Irrigation is consequently patchwork, but enough has been done to demonstrate the miraculous power of irrigation in the San Joaquin Valley.

Mr. P. Y. Baker, civil engineer, for many years devoted to the work, says: "There are about 15,000 acres irrigated in this county, and 950,000 acres not irrigated. There are about 250,000 practically useless without irrigation. Of the above 950,000 there are perhaps 700,000 that produce some crops without irrigation, but very little of it produces fair crops. That is to say, one year with another, the average would be so low that it would be a serious question of making a bare living on most of it. Experience has shown that the proximity of irrigation has added much to the productiveness of non-irrigated lands."

MERCED COUNTY.

In this county provision has been made whereby a considerable area of lands may be irrigated; but the acreage actually subjected to irrigation is small. The famous Crocker canal, which is said to have cost $1,500,000, is situated in this county, and will eventually be applied to a large area. The area of the plain lands which may be profitably irrigated is large.

So far as irrigation has become an accomplished fact in the San Joaquin Valley, it has been done through private enterprise. Under the district irrigation law of 1887 a number of irrigation districts have been organized, and by this means the irrigated area will soon be rapidly extended.

The following districts have been organized in this valley, having the acreage shown:

	Acres.
Modesto irrigation district	108,000
Turlock irrigation district	176,000
West side irrigation district	300,000
Madera irrigation district	330,000
Alta irrigation district	160,000
White River irrigation district	60,000
Poso irrigation district	48,000
Sunset irrigation district (proposed)	285,000
Total area San Joaquin Valley	1,467,000

XVII.—The Next Question is, Will Irrigation Pay?

For more than seven hundred years irrigation has been successfully practiced in Lombardy, which covers a territory of but 9,000 square miles (an extent of country not half so large as southern California), which to-day supports by means of irrigation a population of about 3,500,000 people, and is the garden spot of Europe and of the world. It has paid these people well, and it has built up a country and sustained a vast population; but for irrigation this territory would not otherwise support 500,000 people. Nor do we find the condition of things different in India. There has been expended for the irrigation canals of India, directly and indirectly, $200,000,000. The system of canals there constructed is the most stupendous ever built within historic times. The great Ganges canal is 10 feet in depth and 175 feet in width. It is simply a vast river, and irrigates to-day a million and a half acres of land in a country where irrigation is not only necessary, but where the evaporation is double what it is in Cal-

ifornia. By means of this irrigation, that country produces, with certainty, from two to three crops a year; and this certainty and regularity is a characteristic feature of irrigation. There is no such thing as failure, famine is rendered impossible, and a reasonable reward for labor is made sure.

After examining the official reports relating to the price of water in most of the irrigating districts of the world, the average annual expense is from $1.50 to $2.50 per acre. When only garden spots or small tracts are irrigated the expense is greater.

In California the planting can be done in winter. By irrigation there are no crop failures. Farming becomes a certain business. There are no droughts, no dread of the scorching "northers," no parching of the earth. An uncertainty is changed to a certainty.

It has been estimated that, by irrigation, from ten to twenty times the number of people can live and prosper on the same extent of territory, and this even where there are the usual rains, as in Lombardy. Of course, in parts of India, in Arizona, and in Nevada, irrigation is a necessity. It has been noted in California that the price of lands in districts like Fresno, Los Angeles, and San Bernardino has, by reason of irrigation, increased from twenty to fifty times its original value.

XVIII.—The Temperature of the West is suited to Irrigation.

To present the favorable climatic conditions of the Pacific coast, and especially of California, we append the following statistics, showing the mean annual temperature of the different localities in California, and of foreign countries as well. The statistical information as to the mean annual temperature of Washington Territory, Oregon, Montana, Nevada, Arizona, and New Mexico are not in reach, and can not, in the short time allowed, be presented; but it can be truthfully said that many of the favorable conditions as to irrigation in California are applicable to most of the States and Territories referred to, except that in the western parts of Oregon and Washington Territory the rains are so ample that irrigation is quite unnecessary. In Nevada, Arizona, and New Mexico irrigation must be resorted to that the lands may be made productive; and to that end all the water in those sections should be and soon will be utilized.

Table of mean annual temperature of different localities.

Marysville	63.58	Paso Robles	56.00
Woodland	61.00	Gilroy	58.00
Calistoga	59.00	Livermore	58.00
Auburn	58.00	Merced	63.00
Red Bluff	64.00	Monterey	57.40
Chico	65.00	Colton	62.00
Redding	61.58	Yuma	74.00
Truckee	43.00	Indio	73.00
Napa	59.19	Anaheim	67.00
San Mateo	54.00	Mojave	63.00
Stockton	58.00	Caliente	64.00
San José	56.75	Los Angeles	64.75
Tulare	64.00	San Diego	61.00
San Luis Obispo	57.00	Santa Barbara	60.00

Mean temperature of the following foreign localities.

Turin, northern Italy	53.00	Madrid, Spain	57.00
Florence, northern Italy	59.00	Calcutta, India	68.00
Naples	61.00	Madras, India	82.00
Toulouse, southern France	55.00	Azores	65.00
Toulon, southern France	59.00	Madeira	65.84

It will be observed by the foregoing tables that so far as temperature is concerned California is especially adapted to the purposes of irrigation. If the average mean temperature were too high, like that of Madras, India, the evaporation would be so great that it would be most difficult to carry on successful irrigation, and especially during the hot or summer months.

XIX.—What Interest has the National Government in Irrigation?

The answer is, the whole nation is interested in the subject of irrigation, because *the* whole nation is interested in making the uninhabitable portion of our country *habitable*. *Most* of that part of the United States west of the one hundredth meridian

either requires, or would be benefited by, irrigation. Without it crops are not certain. Thus irrigation not only becomes a question of national interest, but a question of national necessity. This is quite as much so in the United States in relation to this part of the Republic as was irrigation in India to Great Britain, or irrigation in Lombardy to Italy. The vast territory in the United States requiring irrigation covers over one-third of the inhabitable part of our country, and if the national Government can wisely expend millions of dollars in keeping the water off from a portion of the inhabited part of the country, can it not, with equal wisdom, expend wisely money to put water upon that portion of the land which most needs it?

It may be noted that the public lands are almost exhausted; that the preparing of a new country for the habitation and support of a large population is the equivalent of the acquisition of a like amount of territory. By these means the national Government will make useful to the American people what before was of no use. To show the extent of the United States where irrigation would be advantageous, and where it is most necessary, we venture to refer to the territorial area of those States and Territories in parts of which the rain-fall is too light to make farming a certainty:

State or Territory.	Acres.	Square miles.
California	100,992,640	157,801
Oregon	60,975,360	95,274
Utah	54,380,800	84,970
Washington	44,769,160	69,994
New Mexico	77,568,640	121,201
Nevada	71,737,600	112,090
Arizona	72,906,240	150,932
Colorado	66,880,000	104,500
Wyoming	62,645,120	97,883
Idaho	55,228,160	86,294
Montana	92,016,640	143,776

Add to this territory the northern and western part of Texas, which covers an area of about 100,000 square miles and an acreage of 64,000,000, and we see what an empire would thus be brought into practical use. We submit that the oft-repeated argument that the national Government can not afford to promote private interests by national means does not apply to this question, for this is one of national, not one of State or local importance.

The population of our country is increasing at a remarkable ratio. As the population increases, the opportunities for young and ambitious men, who live in the older States of the Union, to gain an honest livelihood, is every year becoming less. Labor is necessarily becoming cheaper. If no more unoccupied lands are made fit for use, land-holding will soon be the privilege of the rich, and tenantry the only hope of the poor. The old adage so often quoted by successful men, that "the fittest succeed," may be true; but unless those who are not "fittest" have an opportunity to establish for themselves homes, the poor will soon vastly outnumber those who are able to help themselves; and when there is little hope for the many, and the Government is carried on for the benefit of the few, neither the property of the one nor the labor of the other will be secure. Indeed, the best safety that capital can have, or that labor may receive, is universal ownership in the soil. Place land within the reach of every citizen. The Government is then secure, because the people are happy. Any system that will open up for settlement a new country, that will change from an arid waste to cultivated fields a region as big as half of Europe, necessarily promotes not only the interest of the whole nation, but benefits the whole civilized world.

Before this Republic should seek to acquire new territory, it should wisely utilize the territory it now has; and it is most respectfully submitted that a national system of irrigation, directed by wise and uniform laws, controlling the rights of water and its uses, will be of the most infinite advantage to the whole American people, and especially if so carried out under the wise supervision of the national Government and engineered by its scientific and experienced men. When this is accomplished there will be ample room in the unsettled portion of the United States to find homes for the millions of people who are to come after us.

Added to this we may say that in considering the interest which the people of the United States have in the subject of irrigation throughout the arid regions of the United States, it is obvious that that interest is paramount. The time is within the recollection of men still young when the population of these United States did not exceed 20,000,000. The time is also readily recalled when the aggregate accession of population by European immigration did not exceed 50,000 per annum. To day, the population of the United States exceeds 60,000,000; and the annual immigration equals, and for the past five years has almost equaled, 1,000,000 per annum. With

the natural increase of 60,000,000 people, reenforced by the artificial increase of an incoming foreign immigration, reaching our shores at that period of life when the generations to be born of them are to be born in our own country, we are fast approaching that period in our national history when the condition known to political economists as the pressure of population will be felt here.

Hitherto, the larger possibilities of the common life of our country have been due largely to the opportunities of acquiring fertile land at primitive or undeveloped values, and enjoying the benefits of the increment which has followed settlement.

Up to the line of the one hundredth meridian, by a general classification, our country is fertilized by a natural precipitation of moisture, sufficient to mature annual crops of cereals. West of that line, with the exceptions of small portions of Washington, Oregon, and California, the country is devoid of sufficient rainfall to mature agricultural crops. The soil is not wanting in fertility. The area embraces over one-third and nearly one-half of the territorial area of the United States. We have already shown that, under irrigation, land is more productive, and its cultivation more certain of profit to the cultivator, where the element of moisture is controlled and directed by means of artificial irrigation. It therefore follows that the application of water to the fertile areas lying west of the one hundredth meridian is to confer upon them a productive capacity even in excess of that capacity now inherent in the lands east of that line. Their fertilization by artificial systems of irrigation is therefore equivalent to acquiring a new territory equal if not superior in fertility to that now occupied by the great body of our civilization. It is therefore equivalent to making room for 60,000,000 more industrious citizens. Nor would this great work, if undertaken, or aided, or even encouraged, in the manner now proposed by the Congress of the United States, be work done in the interest of a population already settled in the territory under consideration. Practically, that portion of the United States lying west of the one hundredth meridian is unoccupied. It is a territory 1,600,000 square miles in extent, occupied by less than 2,000,000 inhabitants. An equal area east of the line of the one hundredth meridian, as has already been shown, is occupied by an industrious citizenship of 60,000,000 inhabitants. The undertaking is, therefore, to be in the interest of the posterity of the 60,000,000 people comprising the citizenship of the United States.

The census of 1880 disclosed the fact that the male citizens of the United States between the ages of twenty-one and twenty-four years, including native-born, foreign-born, and colored, aggregated 2,041,000. Of these, 1,556,000 were native. Assuming the present population of the United States to be 65,000,000 inhabitants, and allowing a proportionate number to the number of the census of 1890, would give about 2,000,000 native-born young men between the ages of twenty-one and twenty-four, and 2,500,000 of all classes. From other statistical facts, it is derivable that at least 1,000,000 young men in each year reach their majority. In each year, therefore, 1,000,000 of the young male inhabitants of the United States reach the age which entitles them to the full rights of citizenship and independent action.

It is most obvious that if the territory lying west of the one hundredth meridian to-day possessed fertility equal to that of the fertility lying east of that line, and if the western territory had yet been unacquired by the United States, and was as sparsely settled or as nearly unoccupied as it is to-day, it would be deemed the highest statesmanship to acquire that territory, in order that the two and one-half million young men between the ages of twenty-one and twenty-four might find a proper field for the exercise of those high faculties of energy and enterprise which the American youth possess. If this be true, the fertilization of this field stands for the exact equivalent of its acquisition. The territory is already a portion of the national domain. Its reclamation, if it is reclaimed at all, will be in the interest of the posterity of the people reclaiming it. The attention our Government will bestow upon it will find all the justification which would attend the attention bestowed by a father upon the possible inheritance of his children. We believe any other enlightened and civilized nation of the earth would accept the possession of such a territory as a valuable inheritance, and would give it the attention we are now seeking at the hands of the Government for the territory under consideration.

England expended $200,000,000—not to reclaim an arid and waste country in India, but for the purpose of adding to the resources of that fertile country the increased capacity which irrigation confers.

The overcrowded populations of Europe are seeking our shores encouraged thereto by the enlarged possibilities of the common life in our country.

Our fiscal systems are directed to the maintenance of high wages to our working classes. The cost of transportation between Europe and America, and the time consumed in the passage, has so far diminished, that the difference between the reward of one week's labor in the two countries will fully compensate the loss of time and repay the passage money.

The conditions with reference to the density of population between Europe and *America are very* rapidly equalizing. If no other new territory is added, either by

way of acquisition from adjacent territory or by the increased productiveness of our own, within the lifetime of children now born the fertile portions of the United States will be occupied by a population equal in density to that of England, Belgium, and France.

The reclamation of the sterile valleys lying west of the one hundredth meridian can be achieved at a cost much less than that which would attend the clearing of a forest and the reduction to a state of cultivation of forest lands.

We are not now proposing that the Government of the United States from its treasury shall construct the instrumentalities of irrigation. What we ask, and what we hope will be granted, is that the preliminary cost of ascertaining all the economic facts necessary to induce capital to enter upon the completion of this great work shall be borne by the Government of the United States, and, when the public lands are effected, make such appropriations as may be wise. Let it once be shown by conclusive data that a reasonable reward awaits the investment of capital in the reclamation of the arid lands belonging to this nation, and private capital will not long be wanting to engage in that undertaking. The necessary capital for the prosecution of any reasonably profitable enterprise is not wanting, when the opportunity for such investment is clearly and officially pointed out. We believe, therefore, that the proposed surveys for reservoir sites, and the approximate ascertainment and publication of the possibilities for the reclamation of the sterile portions of our country, to be in consonance with the wisest statesmanship.

The people of California are more deeply interested in this subject than the people of the other States of the Union, only because of the proximity of the territory to be benefited. The development of a fertility in the soils now sterile for want of artificial irrigation in the portions of our State needing the vitalizing influence of artificial moisture, and in the territory lying immediately contiguous to us, would promote our wealth and prosperity, by building up strong neighboring communities, whose purchasing power would add to our wealth, and by adding that volume of population to our own State so necessary to the establishment and maintenance of a higher civilization.

National life generates a surplus energy which in times past has found war a congenial field for its expenditure. Modern statesmanship addresses itself to directing this national energy into channels of public enterprise. The field under consideration is broad and full of promise in the direction of promoting national prosperity and perpetuating peace.

Respectfully submitted.

M. M. ESTEE, *Chairman*,
W. H. MILLS, San Francisco,
E. W. JONES, Los Angeles,
N. P. CHIPMAN, Tehama,
L. M. HOLT, San Bernardino,
JESSE D. CARR, Monterey,
C. C. WRIGHT, Stanislaus,
FRANK H. CUNNINGHAM, San Diego,
WM. THOMPSON, Reno, Nevada,
Committee.

Mr. ESTEE (resuming). Following that, permit me to say that I think I voice the sentiment of the people of San Francisco and of this coast when I say to you that we are gratified to know that you have visited our State and our city. We have telegraphed to different parts of the State, to representative men who are familiar with the subjects you are investigating. We have gentlemen from the north, like Mr. Green, of Colusa; we have Professor Hilgard, of the university, and we have leading surveyors, Mr. Hall and Mr. Manuel—the latter gentleman having given considerable attention to surveying in Fresno district—Mr. Cunningham, and others, from San Diego. While our gathering here to-day is not large, it is a representative one, so far as those present are familiar with the subject-matter of your inquiry.

The CHAIRMAN. I would suggest that you call the names in the order in which we would be the more likely to get the information condensed.

Mr. ESTEE. As the Government has selected an eminent engineer for this coast, Mr. Hall, I think he should be the first to address the committee. He is an engineer of well-known repute, and has occupied a public station,

STATEMENT OF WILLIAM H. HALL, OF THE U. S. GEOLOGICAL SURVEY, SUPERVISING ENGINEER FOR THE PACIFIC COAST, U. S. IRRIGATION SURVEY.

Mr. Chairman and gentlemen, to review this subject of irrigation as it might be done upon the basis of ten or twelve years of work immediately in connection with it would take more of the time of this committee than I would be justified in taking. Therefore, I have come here to present, in so far as they have been printed, the results of my work, and to say that a condensed and tabulated statement will be the most interesting and useful to the committee.

Mr. M. M. MILLS, of the State Board of Trade. State the origin of the effort on the part of California to make the ascertainments which are now exhibited to the committee, and you will then begin the history of this inquiry.

Mr. HALL. Prior to 1876 there had been but little effort made in this State to systematize or regulate irrigation. But there was an endeavor on the part of the owners of the dry lands through, principally, the San Joaquin and southern valleys to irrigate by means of waters diverted from the running streams. At that time there was a conflict as between those who desired to divert the waters and use them for irrigation and those who were at that time known as cattle-men. They were the owners of large tracts of land, and had utilized those streams solely for grazing purposes. Therefore, the legislature was called upon to enact such laws as would enable the proposed irrigators to divert these waters without hindrance, or at any rate to divert them to a sufficient extent for their purposes. But the legislature had been appealed to for several seasons before to enact laws defining and regulating the diversions, and the proposition met with violent opposition. Some of the leading members of the legislature were those who were interested in cattle-growing. They denounced irrigation as a fallacy, and actually declared that it was a humbug; saying that the plains of the San Joaquin Valley would not grow anything but long-horned steers, at the rate of one steer to 25 acres. But the few who had succeeded in diverting little streams out on the bottom lands, where diversion was easy and the soil rich, knew better. They made strenuous efforts to bring about such legislation as would justify them in this diversion. This conflict led to an investigation of the subject of irrigation generally by the State; which investigation it was supposed would furnish the basis for intelligent legislation.

In 1878, as a compromise measure, was passed a law providing for an investigation of the subject of irrigation. There was tacked on to that law a provision requiring the officer holding the position of State engineer, which had been created by law, to inquire into the débris and artesian drainage provisions. The office of State engineer was created in the spring of 1878, and it was my misfortune to be appointed as the first occupant of that position. That office I held up to within a few months when I was appointed a supervising engineer for the irrigation survey under the Government, and that position I now hold.

The work of the State engineering department started out well, but did not continue. The people thought that when they started out they wanted an investigation of this subject. But when they found that it was going to cost some money it seemed that the majority of the people *did not want* the work. So the work has not been completed. But so

far as the irrigation part is concerned I think enough has been done to show at least what it was intended to be, and to show some valuable and useful results. These results, so far as they have been printed and lithographed, I have thought advisable to present to this committee, and then to refer to them very briefly.

Here [exhibiting volume] is a report made by the State engineer in 1880, covering the subject of irrigation, describing it as it then existed in the then principal irrigation districts of the State, and in the conclusion of the report making certain recommendations with respect to legislation. In this report, I think, will be found the recommendation of the district irrigation bill. But there was in addition to that one to the effect that the State should regulate and control the action of the district. So far as the district idea is concerned it has been adopted and enacted into a law.

Here [indicating] is a collection of reports submitted from time to time since, in all about a dozen in number, touching more or less on the subject of irrigation. Then we come to the final report, in so far as it has been printed.

The CHAIRMAN. You will file those reports with the committee?

Mr. HALL. Yes; although I believe some members of the committee have them. Of course, in studying the subject of irrigation as set forth in the report of the Director of the Geological Survey to Congress, which I have seen, and which I think you gentlemen of the committee are familiar with, you ought to have a knowledge of the topography and general physical conditions of the water supply. Such study was commenced in California, and here is a volume of statistics on California, representing a portion of the work of the State engineering department. There will be found in it, for instance, a compilation of rain-fall statistics for about two hundred stations within the State. There will be found in it a set of tables showing the monthly flow of all the streams in the San Joaquin Valley from Kern River on the south to Mokelumne on the north, and also Sacramento River and valley, with the flow of those streams per month and per second. That is the result of a very considerable amount of instrumental observation and systematic recording. I do not think any other State in the Union, unless it is perhaps the State of New York, can show such results.

Beyond those there are the records of evaporation experiments, which of course have a pertinent bearing upon this water supply and utilization of it, and beyond that is a table of drainage areas, made up from maps of the entire State, showing the water-shed area of each particular stream, and most of the tributary streams within the entire State.

To have carried this work out to a full fruition would have involved very much additional labor, because such information can not be had in a short space of time. No amount of observation will gauge the flow of a stream in one year, or even five or six years; such observations must be made through a period of time. These results cover about six years of actual labor, and several years more of reconnaissance.

Then comes the final report which was projected, a volume which was intended to be introductory to the whole subject, commenting upon irrigation in France, Italy, and Spain, the three irrigation countries of Europe, where the subject has been more closely studied than in any other countries of the world. This book reviews the laws, the customs, the regulations, the organizations for the construction of works, the utilization of water, and the political and financial questions connected

with irrigation. Of course this very largely is a compilation of existing authorities, and from extensive correspondence with governmental officers in those countries. So that from the time of printing, two or three years ago, I have reason to think that it represents a very fair story of the experience of those countries.

Following that comes volume 2 of the final report of the State engineer, which undertakes to describe the existing works in the three southern counties, San Diego, San Bernardino, and Los Angeles. This volume brings the subject down to last September, and describes minutely every work of any note in those three counties, giving the district in which the work is, the work itself, its operation and maintenance, going into the matter of organization; then the water supply available for the work, the use and application of that water, and the history of its organization. So that I think you will find here a very complete story of irrigation as it existed in those three southern counties up to about August of last year. But there has been little change since that. This volume is illustrated with maps.

The CHAIRMAN. Does it give an account of the dams recently constructed in San Diego?

Mr. HALL. Yes; it describes and gives the cost of construction of those dams, etc. This book is illustrated with cuts and pictures of those dams, and it also contains two maps, one of which illustrates the subject of drainage areas within the entire State, showing the division into great areas and sub-areas, with a tabulated statement of the square miles in each area and sub-area; and the other a rain-fall map made up from observations of rain-fall, which observations were conducted by the Department, the Railway Mail Service, and very many other authorities, which shows the distribution of rain-fall for over 10 inches up to 90 inches, and showing where our country is deficient for purposes of precipitation. Then there are other charts, which it is not necessary to refer to here, plans of dams, etc.

There are in this package a number of lithographic maps. One of them represents the San Joaquin and Sacramento valleys, and has within it the great interior valley of the State. It shows every stream correctly located, the topography of the adjacent foot-hills, the slope, and the fall of the plains to be irrigated, etc.

Another map, and on another scale, shows the San Joaquin Valley alone, going more into detail than the general map does, and covering the whole valley, showing the extent of lands actually irrigated.

Then there are ten irrigation sheets, showing every irrigation canal and ditch up to within about three years ago—because this work in that valley was practically stopped three years ago—in the San Joaquin Valley, and the extent of this irrigation in a separate color, and to some extent the character of that irrigation by the shade of that color. So that the story of irrigation in San Joaquin Valley, as it was to be told three years ago, is in graphic form for the inspection of the committee.

Then there are twelve detailed irrigation sheets relating to San Bernardino and Los Angeles Counties, going more into detail than those relating to the San Joaquin valley. These twelve sheets now for the first time appear before the public, but the other sheets I think the committee have received.

The CHAIRMAN. Has there been any change in the San Joaquin valley in the last four years?

Mr. HALL. Yes. I have just come to that point. These twelve sheets *relating to the* southern counties are more in detail, as I said, and on a

larger scale than in the San Joaquin valley, and they show, down to last August, every bit of land irrigated to that time, and the character of the irrigation.

Now, the tabulation of this data, while it has been for some time in course of preparation, was in a measure checked for want of funds for completion. And I have certain tables, copies of which I shall furnish to the committee. Here [exhibiting] is a table showing the division or district in each river from Kern to Mokelumne, which covers the irrigation portion of the great interior of the State. It shows the data of each county, its length, dimensions, etc.; its claim to water, and equivalent of that claim, the period of flow, the period of time during each season that it ordinarily has water, the greatest average flow for three months during the season of 1885, and the cost of the works so far as such cost can be ascertained or even approximately estimated, and the amount of land irrigated in acres for each cubic foot per second of continuous flow for three months. That tells a very complete story of the irrigation of that valley at that time. In course of preparation I have a supplement to this table which brings the work down to last season, in some cases quite accurately, and in other cases approximately. (See Exhibit A.)

The CHAIRMAN. When will that be completed?

Mr. HALL. I will have that before the committee before it will be required.

Then there is a table showing the irrigation of each canal in the three southern counties, naming it, and giving the extent of its application, being a synopsis of the data in the second report. That table I will hand to the committee to keep; the other I will have to retain for the present (Exhibit B), but will forward.

The CHAIRMAN. Are you through with the State work?

Mr. HALL. Yes, so far as presenting this printed data is concerned. Irrigation in this State has advanced not only the marketable value of the land, but the actual value of land from practically nothing up to from $100 to $500 per acre. The marketable value of the land has advanced in some instances to $1,000 and $1,200 per acre. But I say the actual value of the land is from $100 to $500 per acre. In broad terms that is the economic value of irrigation which every one can understand.

The CHAIRMAN. Will your reports approximate the average cost per acre in irrigating in the first instance?

Mr. HALL. Irrigation has cost, by the crude, home-like methods which the ordinary farmers individually have practiced, from $2 to $5 an acre. By the better methods pursued and by better organized companies, by men commanding capital, with more substantial works constructed, it has cost from $2.50 to $10 per acre.

In the southern part of the State, where water is scarce and where the results of water are measured in oranges and in raising grapes, they have lined the ditches with concrete. Sometimes they line them with wood, sometimes with asphaltum, at other times they line them with brick, and in many cases with stone laid in cement. In other cases ditches have been dispensed with, and pipes have been laid; large concrete pipes, like a sewer in a city, or large iron pipes, such as would astonish some persons engaged in water supply works for cities. In those cases irrigation has cost more to the acre. The cost of such work has amounted to from $15 to even $40 an acre. But there the land has been practically valueless without irrigation, and it has commanded from $250 an acre to $750 an acre when water was put on it. So that, you may say that, according to the work, irrigation has cost from $2.50

an acre to $50 an acre in this State. And, as a matter of course, the cost in every instance presents a peculiar problem. If we start out to irrigate a small bit of bench land, we must expect it to cost very much more to the acre than it would to reclaim a great desert. There have been instances where irrigation works, simple open ditches and the ordinary methods of construction, have cost very much more than the ordinary price. But there are instances where large areas have been reclaimed and have cost less. As in every other business, we may say, when you undertake to irrigate a portion of the Colorado desert by the diversion of the Colorado, or the barren lands of Modoc and Siskiyou Counties by the Pitt River or the Owens, with such work as that and a large capitalization to carry it through, you can bring the cost per acre down, and the Government, if it should move promptly in the matter, might carry out the work at 25 per cent. of its ordinary cost.

The CHAIRMAN. You class the irrigated land at from $100 to $500 per acre?

Mr. HALL. Yes.

The CHAIRMAN. And that you apply to nearly every locality in the State?

Mr. HALL. Yes; those figures will cover every locality in the State.

The CHAIRMAN. What crops do they produce?

Mr. HALL. Grain on some lands, if properly prepared, $200 an acre and $300 an acre can be maintained; but the generality of experience with grain in the State does not justify the cost. It is more trouble and more expense to irrigate land for grain than for any other crop.

The CHAIRMAN. How as to grasses?

Mr. HALL. Alfalfa you can speak of in about the same class as grain, but generally with grasses. If you want to irrigate alfalfa economically you must spend the money on the land, that is on the irrigation works at first, in order to be able to cover that land with the least amount of water.

Senator STANFORD. Is there any acre of land in this State in alfalfa that can be irrigated and made to produce an income of $100?

Mr. HALL. There is no area of fair valley land but will produce fully to that valuation. Of course, there are areas of land which to the eye will look pretty well, but they are not fair lands for irrigation purposes; they are alkali lands, and heavy in the soil. The expert will recognize that at once. But they are the exception. It does not make so much difference if you have alkali on the land, because experience in this State has shown if you have alkali combined with clay, light alkali land, it can be handled very well, but the heavy alkali lands can not be.

The CHAIRMAN. When you have alkali lands do you reclaim them by putting water on to them and paying attention to the drainage?

Mr. HALL. Yes. There must be more attention paid where the land is covered with alkali than where it is not.

The CHAIRMAN. What would be the proper way?

Mr. HALL. It depends on the amount of cultivation, the expense that would justify the return expected. Where you have only general agricultural and not horticultural farming, the method of open ditches, with closed conduits, is the only method that would be justified.

Mr. MILLS. Before Mr. Hall leaves the question of the valuation of land, I would like to ask him a question. What increment of value, as a general proposition, is conferred upon the land by irrigation. That is to say, take the average valuation of irrigable land in the San *Joaquin* valley. Without irrigation, in its natural state, what would it *be worth, and* what value would be conferred upon it, or what percent-

age or increment of value would be conferred upon it—how many times its present value would it be worth with irrigation?

Mr. HALL. Of course, in answering that question one would have to predicate his answer of the present value of lands there. But what dry lands are held at in the San Joaquin Valley is not a good criterion. The present value of dry lands down there without water and without the hope of getting water, does not exceed $10 per acre. You can buy them for that. But it does not exceed that. I speak of the Tulare portion, and not San Joaquin.

Senator STANFORD. Is not this $10 an acre valuation based upon the possibilities of irrigation?

Mr. HALL. No. It is by reason of the neighborhood of irrigated lands. These dry lands are rendered more valuable, actually, because of their proximity to irrigated lands than they would be without the irrigation in the neighborhood. They can be utilized in many ways. But without that irrigation near there, without that population which irrigation sustains—wipe out irrigation in Tulare Valley and set it back thirty or twenty-five or even twenty years, and the land will go down to $1.25 an acre.

Mr. MILLS. That is my question. Where irrigation has been projected how many times does the value of the land increase?

Mr. HALL. Two hundred fold.

Mr. ESTEE. Take Riverside, for instance.

Mr. HALL. I am speaking of agricultural lands generally. Riverside is an exception. A horticultural neighborhood must be the exception. We can not expect to practice horticulture on the great body of the arid region. Riverside land, of course, has gone up from $2.25 an acre to $600 an acre, or, perhaps, $1,000 an acre.

The CHAIRMAN. How much land would it have required to support one head of cattle, one ox, in the San Joaquin Valley before there was irrigation?

Mr. HALL. I have had no experience in that direction; but I remember to have heard in the legislature of the State a discussion in which Hon. Thomas Fowler, a well known cattle man in early times, took part. It was he who was the great opponent of irrigation. I heard him declare, in 1876, that the plains of the San Joaquin Valley were valuable to him and others in the same business with him to the extent of one long-horned Mexican ox to each 25 acres. He was good authority then.

The CHAIRMAN. How many horned cattle will an acre of well cultivated alfalfa now support?

Mr. HALL. Two or three. There are better witnesses upon that point, however, than I am.

The CHAIRMAN. I would like to hear about the Government surveys, whether any good can be accomplished in California by having them go on. You have undertaken these surveys.

Mr. HALL. I might be considered a prejudiced and biased witness upon that point, seeing that I am interested in them. But, taking my statement for what it is worth, I think there is a very great necessity for just such an examination as the Government has undertaken. The necessity in California is not confined alone to the valley land, but generally, for purposes of water supply, for domestic purposes, and for the prevention of floods, for the amelioration of the sanitary condition of the country, and for the reclamation of the land—all of these ends will be subserved by such a study as that which has been commenced. For instance, taking the Sacramento Valley, a valley with some hundreds of thousands of overflowed lands in it. Those lands can never

be reclaimed unless there be some systematic work in controlling the floods, in controlling the rivers. Such work can not be undertaken without a physical study of the hydrological conditions in that valley. That study must be based upon a knowledge of the topography of the country, of the opportunities for storing water, and, of course, of the water supply, and the manner in which that supply is had. This study undertaken by the Government will furnish the foundation of the reclamation of 1,000,000 acres of land overflowed annually, or for the protection of hundreds of thousands of acres which have been partially reclaimed, but are threatened every few years with inundation.

In the San Joaquin the question of water supply for purposes of irrigation is more especially important, and this study will enable the people of the State, and especially those living in that valley, to know where and how water can be stored and served for purposes of irrigation. The Government owns some arid lands in that valley, especially on the western side and of course the valuation of those lands will be affected, as I have stated, perhaps 100, 200, or 300 per cent. by reason of this work. I have spoken of that portion of the State where irrigation is less needed, unless we take into consideration these coast counties, and the people there are too well off to want any Government aid.

But going back in Siskiyou and Modoc Counties, there are a million or so acres of land, and that land is largely the property of the General Government. That can in a great measure be reclaimed by the storage of water and the diversion of water from the larger streams. Such storage and such diversion, in my judgment, can be carried on only upon the basis of such a study, because the problems there are too much in private enterprise, and unfortunately or fortunately, as you may consider, the laws of our State are in such a condition that private enterprise is afraid of such investments, unless there be some governmental scheme to carry it out. So that, in some sections of our State, private enterprise is at a standstill as to undertaking great irrigation works, and unless the Government should do something in the way of demonstration of the possibility of the inaugration of the great works, new ones in this State will very soon cease. Of course, on the eastern side of the mountain, in what is called the La Hontan division, you can hear from Mr. Bridges, who has charge of that work, what can be accomplished by irrigation. But going south into the Mohave and Colorada Deserts, in the Colorado Desert there is a country 25 miles broad and 50 miles long that can be very largely irrigated by the diversion of water from the Colorado River. That is a scheme which the Government alone should undertake, in my judgment. I do not think any private enterprise should undertake that unless it were by governmental authority. The scheme is a big one, and the chances are too great, the time necessary for carrying it out too long, and the conditions too complicated for private enterprise, at least in our generation.

The CHAIRMAN. To what extent for reservoir sites in this State does the Government still own land?

Mr. HALL. In the northern part and eastern part of the State—the northern part, that is, exclusively the coast valley and the great interior valley—the Government yet owns very largely the land, and we might say that the opportunities for storing water in those portions, that is in the eastern portions and northern portion, even, than any other section of the State where irrigation is now considered necessary.

The CHAIRMAN. Are you familiar with the high mountains that form the water-shed of the Kern and the other rivers from there up to Stockton?

Mr. HALL. I am.

The CHAIRMAN. Are there many lakes in the high mountains along there?

Mr. HALL. In the Kerr Mountain water-shed there are exceptionally good opportunities for water storage. There is one remarkably fine chance there. It is called the Manatechee meadows. It has been surveyed. It was surveyed by the State engineering department in 1880, and it has been since surveyed by private enterprise. It is a mountain meadow, having a very flat surface and broad expanse, where a dam for impounding water to a maximum depth of 80 feet could be built. A dam 400 feet long on the top will retain 6,378,000,000 cubic feet of water, covering an area of 4,420 acres. I do not think there is another available water site in California, unless it be some big natural lake like Lake Biglar, Clear, or Goose Lake, that form similar opportunities.

The tabulated results of storage of water in California, by great hydraulic dams, and dams constructed for municipal purposes for the supply of San Francisco and Oakland, and dams constructed in the southern part of the State for irrigation purposes, with a liberal estimate for this site—the cost for that place will be somewhat less than one-half to the volume of water than any other site surveyed—I propose to hand to this committee, and not consume your time with them now.*

There is one question I find to which, perhaps, justice has not been done; a question about which this committee ought to carefully avoid hearsay, because I know it is after the truth—bottom facts. That question is the duty of water. You will find, for instance, in the San Joaquin Valley that claims are made that a cubic foot of water per second will irrigate 200 or at any rate 160 acres of land. Now, it is not doing it. We have the acreage irrigated platted out definitely on a map, and the name of every man who irrigates every piece of land. We have the canals measured, and have observed through not one season but several of them, and I find that a cubic foot of water in the San Joaquin Valley does not irrigate 160 acres of land. But that is not because a cubic foot of water will not irrigate 160 acres, but because it is wasted. It is wasted because this State has never properly regulated the matter. That is the reason.

Senator JONES. Do you think a cubic foot is sufficient to irrigate 160 acres of land if properly managed?

Mr. HALL. I think that a cubic foot of water properly managed with open ditches carefully constructed can be made to irrigate 160 acres of land in the San Joaquin Valley; but it will take supervision.

Senator JONES. What depth of water, of actual irrigation, will that give?

Mr. HALL. I have not calculated that part of it, but I can easily do so.

The CHAIRMAN. That is a cubic foot during the irrigating season?

Mr. HALL. During the irrigating season—the four or five months of irrigation.

The CHAIRMAN. Does it require more or less water at the beginning of irrigation?

Mr. HALL. Oh, vastly more. In 1876, I think it was, or 1877, I was temporarily in charge of some canals which had been constructed in Fresno, and which, through the failure of one of the large land owners there, had gone into the hands of one of our local banks, and one season, as representing the bank there, I visited that canal and measured over and over again the amount of water which was applied to a 20-acre

* *These tables* have not come to hand.

tract. That 20-acre tract was down at the end of the irrigated area, and it was in a new country surrounded by a broad expanse of absolutely dry plain, and just where this tract was situated the soil was 60 feet below the surface. I have run on to that tract of land enough water to cover it 23 feet deep in one irrigating season. I have run that much on over and over again. Of course, that tract of land was simply a little sponge through which the water sunk. Taking a level cross-section to get a profile of the country, the San Joaquin on the north and Kings River on the south, and then measuring from the surface down, we found that water on the plain with this irrigating water on top sloughing away. Now, irrigation has gone on there for thirteen years more—I am not certain about just that locality, but within 2 or 3 miles of there—the water stands on the surface of the ground, and flags and rushes grow there, and, if no Fresno gentlemen are here, I will say that chills and fever grow there too. That is the effect.

The CHAIRMAN. It needs drainage now?

Mr. HALL. Yes.

The CHAIRMAN. You were about to give the duty of water?

Mr. HALL. Going into the southern counties where water is applied for different purposes, horticultural purposes almost entirely, through cemented ditches, wooden flumes, and iron pipes, it is claimed that the inch, which is about one-fiftieth per cent. of a cubic foot per second, will irrigate 10 acres. Of course, that will be 500 acres to the cubic foot per second. But it does not. The inch will irrigate 10 acres of young oranges, where the water is applied around the base of a tree with a hose, or to wet a place two feet square around a young orange tree or grape vine. But experience at Riverside, where irrigation has been carried on longer, shows that the inch irrigates from 2½ to 3 acres.

Mr. N. P. CHIPMAN. State what an inch of water is in this country.

Mr. HALL. The inch in this State is very much like the old lady's piece of butter in her receipt for cake, and so according to local custom the inch varies about 100 per cent. of its minimum value. But measuring water through a 1-inch orifice, under a pressure of 4 inches over the top of that orifice, we will get the equivalent of about one-fiftieth of a cubic foot per second. And so, while not accurate, for convenience, in order to translate the inch into a definite quantity, I have adopted in this State engineering the co-efficient of 50. I divide it by 50, or multiply it by 50, to get the cubic foot, and I think that has been adopted by engineers in the southern part of the State.

But to go back. On page 219 of the second volume of the report of the State engineer, can be found a statement of irrigation at Riverside, showing the capacity of the canals in inches, the low water in miner's inches, and the overflow in miner's inches, and the extent of irrigation. The figures for 1888, the last year of observation, are all marked there, and have approximates, because in that year we did not actually measure the amount of land irrigated, but upon the basis of those which preceded and from returns made by the irrigators in writing, we get very closely to it, and the last figure is not far wrong. You will find then that with an ordinary flow of 3,500 miner's inches in the Riverside canal during the irrigation season, there were 6,500 acres irrigated. There you will see that it is actually less than 2 acres to the inch.

There are a great many ways in which water is lost in irrigation. But you measure water and run it onto a tract of land for a few hours at a time and you will find its duty mounts up comparatively high. But you must remember there is a loss in transmitting water through the *main canal*; there is a loss in distributing; there is a loss in managing it,

and there is a loss in the actual irrigation in the waste off from the tract irrigated. And so, while I do not say as a matter of fact that the extent of the duty of water in Riverside has been reached, or that it has been reached in any other of those colonies down there, still I do say they will never irrigate 10 acres to the inch as is claimed. If they make it 5 or 2½ acres to the inch, the water carried in closed conduits and in the best class of work, they will be doing very well.

The CHAIRMAN. Have you ever made any observations with a view to determining what effect irrigation will have upon the climate?

Mr. HALL. There have been curious climatic changes in this State which we must attribute to irrigation. For instance, I remember to have gone to Bakersfield some years ago when irrigation was first being introduced there. I do not know whether this ought to be recorded, but I was struck with the very curious appearance of shape of the younger ladies or girls in that section. It seems that I could not account for it at the time, but it turned out that they had a little affection of the spine, and there was a rotundity of the trunk which was astonishing in ladies so young. I tell you that to illustrate the fact that before irrigation was regularly introduced, there was a malarial influence which pervaded the population to that extent, and it showed not only upon the countenance of the people, but upon their persons. But now that the slough has been cleaned out, the underbrush cut away, the rank vegetation ploughed off, the surface of the land turned over to the atmosphere, fresh water brought over these sloughs and applied to the land and vegetation, the atmosphere and the climatic conditions appear to have changed to that extent that I believe Bakersfield and that neighborhood is about as healthful a locality as you will find in any portion of this State. And I attribute it to irrigation.

Mr. CHIPMAN. The popular idea all over the world is that irrigation produces malaria, and is so unhealthful that it is discarded in many localities. You can not be too emphatic on that point.

Mr. HALL. I was just coming to that. Here in Bakersfield is one instance where the cultivation of land by irrigation has greatly improved the health of the people. Bakersfield was comparatively a low section. Going up to Fresno we have a high section. At Bakersfield the ground waters were within 10 or 15 or 20 feet of the surface—that is when I saw it—I mean the neighborhood. At Fresno, the ground waters were 60 or 80 feet below the surface before irrigation. That country has been filled up like a sponge, and there has been no adequate drainage. The water enters subterraneously the cellars of Fresno and flags grow upon the formerly dry plains. There is no doubt that Fresno is a much less healthful place than it used to be. But it is not due to irrigation. It is due to the lack of drainage. Fresno can be as healthful a section as it ever was or any other section in that portion of the State.

The CHAIRMAN. Must this drainage be expensive?

Mr. HALL. No, it need not cost any more to the acre than to irrigate.

The CHAIRMAN. Will the drainage cost as much as the original irrigation works—the cost of bringing the water onto the land?

Mr. HALL. A proper drainage of Fresno would not cost as much as the irrigation of it. But it is not irrigated yet, and the full expense of irrigation is not known there. Generally speaking there are instances where irrigation has been practiced in a crude way, where apparently the healthfulness of the climate has been affected, where chills and fever and malarious effects have come with irrigation; but they can be traced to the lack of drainage as we can trace typhoid fever or those low

grades of fever which pervade sections of this State to defective sewer drainage in the houses. I know a family in this town that has been driven out of three houses, that is to say, it has gone into three separate houses where it has turned out that the drainage underneath the ground was moistened with sewage matter. You can not have healthful houses on the plains of Fresno with the water standing in your cellar any more than you can with the sewage water in your house in this city.

The CHAIRMAN. How does it affect rain-fall?

Mr. HALL. The experience of this State has been too limited to speak definitely upon that point. You will find a great many intelligent gentlemen here who believe that irrigation has thus far increased the amount of precipitation, and I do not think any of us are prepared to dispute it without facts. But it seems curious. Over a series of years since irrigation was practiced in Los Angeles County, the rain-fall has been greater, and the same can be said of San Joaquin Valley. But what time is necessary we do not know.

Senator JONES. Have there been observations for a sufficient length of time to determine that?

Mr. HALL. No. I file with the committee tables, etc., marked respectively Exhibits A and B.

EXHIBIT A.

The canals of San Joaquin Valley—Irrigation data for 1885.

	Acres.
Kern River, north side:	
Pierce and Barker (no irrigation)	
Barker and Wilson (no irrigation)	
Kern River, south side:	
Barker	100
Kern River, north side:	
Beardsley	1200
McCord	2,000
Calloway	18,000
McCaffrey Slough	300
Emery	80
Jones and Turkey (no irrigation	
Railroad, Wible, Goose Lake	360
Pioneer	4,080
Edwards (no irrigation)	
James and Dixon	960
Johnson	360
Ashe (no irrigation)	
May (no irrigation)	
Joice	640
Kern River, head of Joice canal:	
Dixan	100
Kern River, south side:	
Kern Island	10,170
South Fork	3,675
Farmers	1,780
Castro (no irrigation)	
Stine	7,000
Anderson, Gates	1,400
Buena Vista	2,480
James, *Plunkett*	4,800
Meacham	280
Kern River, south side—Cont'd.	
Wilson	100
Henly (not in use)	
Frazier (not in use)	
Kern Valley Water Company's west-side canal.., Kern Valley Water Company's east-side canal...	3,500
Total	63,365
Poso Creek:	
Purcell	400
Creasey (unfinished)	
Deer Creek:	
Wingfield	300
Carothers (no irrigation).	
Deer Creek, consolidated ditch	1,335
Total	1,635
Tule River:	
Great American	50
Pioneer	1,292
Traylor	60
Porter Slough	53
Hockett	314
Wallace	40
McGee, Putnam, and Caldwell	110
Gilliam	120
Hubbs and Miner	405
Fulweiler	152
Hunsaker	160
Platts	10
Thomas	5

EXHIBIT A.—*The canals of San Joaquin Valley, etc.*—Continued.

	Acres.
ule River—Continued.	
Elrod	31
Brown and Ray	10
M. M. Burnett	40
W. T. Burnett	166
Bacigalupi and Chreighton (no irrigation).	
Bond	80
Klein (not in use).	
Royerr, jr., School-house Branch of Tule River (not in use).	
Royerr, jr., Stadtmiller, (not in use).	
Lamacsna (not in use).	
Bacigalupi	170
Wilcox	80
South Tule River	15
Plano	408
Vandalia	100
Rose	18
Mitchell, Springer, & Rose	44
South side	754
Fine	576
Collisium Slough	634
English	120
Stockton	681
Ball & Harrison	190
Empire	160
Woodville	100
Tipton	254
Janes (no irrigation).	
Lone Oak Slough (no irrigation).	
Hirely (from L. O. Slough)	20
Creech (from L. O. Slough)	40
Rogers (from L. O. Slough) no irrigation.	
Fancher	293
Small	160
Firmly (no irrigation.)	
Gully (no irrigation).	
Small and Woesling	160
Total	8,075
Kaweah River:	
Wutchumna	1,634
Curtis & Lindsley	48
Venice	81
Elbow Creek (no irrigation).	
Matthew	267
Curtis (not in use).	
Weston (not in use).	
Uphill	596
Settlers	4,934
Lakeside	9,167
Upper Pogue (no irrigation).	
Lower Pogue	100
Ogden	80
Hamilton	30
Consol'd't People's Ditch	4,065
Farmers	645
Kaweah	3,121
Tulare	402
Rocky Ford (no irrigation).	
Cameron	1,372
Bacon & Crossmore	2,270
Judd (*abandoned 1868*).	

	Acres.
Kaweah River—Continued.	
Evans & Turner (not in use).	
Kaweah and Mill Creek	1,425
Chatter (from Kaweah and Mill Creek)	150
Oaks (from Kaweah and Mill Creek)	150
Evans (from Keweah and Mill Creek)	289
Burch (from Kaweah and Mill Creek)	110
Watson (from Kaweah and Mill Creek	315
Mill (from Kaweah and Mill Creek) used only for water-power.	
Jennings	506
Hicks and Weston	50
Royers	55
Modoc	809
Holladay (no irrigation)	
Upper Hayes / Lower Hayes	700
Channels from St. John's Channel to Kaweah River:	
Long's Canal (no irrigation)	
Ketchum Cut (no irrigation)	
Bostwick Cut (no irrigation)	
Total	33,371
King's River (north side):	
King's River and Fresno	3,935
King's River (branch of Fresno Canal):	
Centerville	
Fresno	25,045
Fowler Switch	4,059
Centerville and Kingsburg	9,116
Emigrant	4,781
Lagmade Tache	9,085
Liberty	1,242
King's River (north side):	
Millrace	390
Reed	160
King's River (south side):	
"76"	2,200
Kincaid, Morrow, Glerm, Barton — Small private ditches in Centerville bottom.	200 / ... / ... / ...
People's	16,545
Mussel Slough	
Last Chance	13,436
Lower King's River	6,622
Rhoads	2,735
Total	99,551
San Joaquin River:	
Upper San Joaquin	600
Chowchilla	6,900
San Joaquin and King's River	23,835
Posey Slough	
Temple Slough	
Santa Rita	400
Total	31,795

EXHIBIT A.—*The canals of San Joaquin Valley, etc.*—Continued.

	Acres.
Fresno River:	
Fresno Dam and Canal Co.'s canal	5,416
Adobe Ranch	350
Total	5,766
Chowchilla River:	
Kohler, West, and Minturn	850
Minturn	40
Total	890
Merced River:	
Merced Falls	198
Murray Hill	165
Snelling	423
Montgomery	153
Ingalsbe Slough	202
Scott	130
Deane	449
Old River	1,142
Old River:	
Grade slough (fr. Old River)	
Sellman (fr. Old River)	
Means (fr. Old River)	
Grade (fr. Old River) not in use.	
Merced	2,000
Feldhams and Reed	407
Griffith and Sharer	550
Hamlin	127
Total	5,946
Tuolumne River:	
Wheaton	50
Stainslaus River:	
San Joaquin County	184
Pentland (not in use 1881)	
Mokelumne River:	
Barnett	112

SUMMARY.

Supply from—	Name of canals.	Irrigated area.
		Acres.
Kern River	Kern River canals	63,365
Poso Creek	Poso Creek canals	400
Deer Creek	Deer Creek canals	1,635
Tule River	Tule River canals	8,075
Kaweah River	Kaweah River canals	33,371
Kings River	Kings River canals	99,571
San Joaquin River	San Joaquin River canals	31,795
Fresno River	Fresno River canals	5,766
Chowchilla River	Chowchilla River canals	890
Merced River	Merced River canals	5,946
Tuolumne River	Tuolumne River canals	50
Stanislaus River	Stanislaus River canals	184
Mokelumne River	Mokelumne River canals	112
Total		251,140

EXHIBIT B.

Actual irrigation. San Diego, San Bernardino, and Los Angeles Counties, 1888.

SAN DIEGO COUNTY.

Group, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
San Diego and San Dieguito Rivers.	San Diego River	South Fork (old ditch; Indians)	50
	San Diequito River	Bottom Lands (old ditch)	100
	Do	San Pasquel Valley (old ditch)	175
	Do	Santa Ysabel Rancho (old ditch; Indians)	100
	Guejito branch Diequito River.	Guejito Branch of San Isabel (old ditch)	25
San Louis Rey River		San Louis Rey Mission (old ditch)	100
		Montserrate Rancho (old ditch)	65
		Vicinity of Pola, 5 or 6 ditches (old ditch)	200
		Aqua Tibia Creek (old ditch)	65
		Panna Creek (old ditch; small patches)	
		Cuca and Warner's Ranchos (old ditches; Indians)	50

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

SAN DIEGO COUNTY—Continued.

roup, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
Iargarita River.		Santa Margarita Rancho (old farm ditch).	312
iento River		Huiler Ditch	55
		Hewett's Ditch	450
		Estudillo Ditch (abandoned)	.....
		Mission Indians Ditch	150
		San Jaciento town ditch (around town)	.....
		Webster's Ditch	75
		McAllister's Ditch	75
		Palm Valley Land and Water Company	160

SAN BERNARDINO COUNTY.

Santa Ana River.

.na Cañon group	Santa Ana River	North Fork Canal:	
	North side	Highland Vineyard Canal Crain, Van Lueven Canal	1,400
	South side	South Fork or Sunnyside Canal	1,535
		Red Lands Ditch J & B Ditch	1,200
	Bear Valley Company.	East Red Lands Company Works	150
		West Red Lands Company Works	150
Diversion group	Santa Ana River	Riverside Water Company: R. Lower Canal	
	Warm Creek	R. Old Upper Canal R. Warm Creek Canal	6,580
le mesa sub- (*a*)	Artesian wells in San Bernardino Basin.	Upper Riverside Enterprise Gauge Canal	1,100
		Highest Riverside Mesa Scheme:	
		Vivienda Water Company (no irirgation).	.....
		N. Riverside Land and Water Company (no irrigation).	.....
		Jumpa Land and Water Company (no irrigation).	.....
Diversion group	.....	Camp Carlton Ditch	415
		The Old Hunt Ditch	125
		Old Jansen Ditch	132
		Belarde & Salazar Ditch	55
ide Santa Ana roup (*b*).	Hunt's Springs	Hunt's Spring Irrigation	30
	Four artesian wells	Filanc Wells Irrigation	42
Creek and City sub-group (*c*).	Warm Creek	Hawes Ditch	50
	Warren Creek and wells.	Rabel's Dam Ditch	375
	Do	Stout's Dam Ditch	240
	Warm Creek	McKenzie or Lower Dam Ditch	325
	Lower City Creek	Spark's Ditch	20
	Do	Stewart's Ditch	47
	Do	Waterman's Ditch	55
	Do	St. Bernard or Davis Mill Ditch	.....
	Heap Springs	Heap's Springs or Beam Ditch	70
	Artesian Springs	Johnson's Swamp Ditch	115
	Artesian	Coburn Swamp Ditch	56
Creek Springs Town Springs roup (*d*).	Raynor Springs	Rancheria Ditch	180
	Do	Cotton Land and Water Company's Ditch.	204
		Town Creek Ditch (no data)	.....
		Beamis Ditch (no data)	.....
		Garner Ditch (no data)	.....
Diversion group	Santa Ana River	Santa Ana Waste-water Ditch	300
ide Santa Ana roup (*e*).	Warm Creek	Meeks and Daley Ditch	385
	Santa Ana River	Jaramillo Ditch	30
	Do	San Salvador Ditch	50
	Do	Aqua Mansa Ditch	116
Plains sub- (*f*).	.....	North Riverside Land and Water Company; Vivienda Company; Jumpa Land and Water Company. (Projects only.)	.....

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

SAN BERNARDINO COUNTY—Continued.

Group, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
Jumpa Valley group (3).	Santa Ana River (west side).	Jumpa or Rubidoux Ditch	557
	Riverside Lower canal.	Trujillo Ditch	250
	Santa Ana River	Linville Ditch	75
	Do	Soucal Ditch	100
	Do	Brickmore or Island Ditch	120
		Hall Ditch	100
Rincon group (4)	Santa Ana Lower Cañon.	Yorba Ditch	485
	Santa Ana River	Fernandez Ditch	279
	Chino Creek	Taylor Ditch	6
	Rincon Mill Creek	Cota Ditch	50
	Do	Spring Valley Ditch	47
	Spring Valley Waste	Fuqua Ditch	66

San Bernardino Valley Works.

South Cañon group (5)	Mill Creek	Old Zauja Crafton Water Company	1,300
	Crafton Main	Red Lands Heights, Main	.....
	Bear Valley Canal	Crafton, Lugonia and Redlands Domestic Water Company. (No data.)	.....
	Yucuipa Creek	Yucuipa Ditch, a small ditch in Yucuipa Valley. (No data.)	166
	San Timoteo and Elder Creeks.	Several ditches (small, no data)	.....
North Cañons group (6)	City Creek Cañon	City Creek Ditch	203
	West Creek	West Twin Creek Ditch	70
	Do	Waterman Hot Springs Irrigation	40
	East Creek	East Twin Creek Ditch (abandoned)	.....
	Cajou Pass stream	Glen Helen Ditch	200
	Lytle Creek	Rialto Canal	602
	Do	Semi-Tropic Land and Water Company	475

Cucamonga Plains Irrigations.

Cucamonga Plains groups (7).	Day's, Young's, and Middle Cañons.	Etiwand Colony Irrigation	652
	Deer and Alder Cañons.	Hermosa Water Company	388
	Small intermediate cañons.	Sausevain's Ditch (abandoned)	.....
	Cucamonga Cañon	Iowa Colony Irrigation	301
	Do	Cucamonga Development Company, Cucamonga Water Company's Works.	1,940
	Cucamonga Cañon and Cienegas.	Cucamonga Vineyard Company	350
	San Antonio Cañon	San Antonio Water Company	1,750

LOS ANGELES COUNTY.

Cucanwuga Plains irrigations.

Pomona (1)	.....	Pomona Land and Water company's works:	
		Old settlement ditch	455
		Irrigating Company of Pomona	1,880
		Palomares Irrigating Company	430
		Del Monte Irrigating Company	520
		Cañon Irrigating Company	2,040
		Packard works	(?)
		Fleming & Rohrer	(?)
		Chino	(?)

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

LOS ANGELES COUNTY—Continued.

San Gabriel Valley irrigations.

Group, etc.	Supplied from—	Name of corporation or ditch.	Irrigated area.
			Acres.
ı Madre Cañons up (2).	San Dimas Cañon.....	San Dimas Land and Water Company.....	100
		San José Ranch Company.....	125
ſosé subgroup....	Dalton Cañon.....	San José Land and Water Company.....	(?)
·abriel River sub- ıp.	....	Glendora Water Company (no irrigation).....	.....
		Dalton or Azusa Ditch.....	2,550
		Azusa Water Development and Irrigation Company.	1,500
		Duarete Mutual Irrigation Canal Company.	600
		Beardslee Water Ditch Company	500
Anita subgroup	San Pit Cañon.....	Bradbury-Monrovia Works	50
	Santa Anita Cañon...	Santa Anita Water Company	(?)
	Little Santa Anita Cañon.	Sierra Madre Water Company	300
Madre cañons ıp (2).	Davis' Cañon	Sierra Madre Villa and Vosburg Companies.	105
		Kinnola Ditch.....	60
asquel subgroup	Eaton Cañon.....	Precipice Cañon Water Company.....	250
	Rubio and Les Flores Cañon.	Rubio Cañon Water Company ..... Rubio Cañon Land and Water Association Les Flores Water Company.....	200
group (3).....	San Gabriel and Santa Anita Cienagas.	Santa Anita Rancho.....	150
		Marengo Water Company.....	
		Alhambra.....	6,000
		Alhambra Addition Water Company....	
		Old San Gabriel Irrigations.....	
	San José Creek	Phillips Ditch	50
		Fryer's Ditch	100
		Rubottom Ditch.....	40
		Wright Ditch.....	60
		Currier Ditch.....	150
		Rowland and Foster Ditch.....	200
		Ybarra Ditch.....	350
		Quintana Ditch.....	100
		Monroe Ditch.....	40
		T. and J. Rowland Ditch.....	250
		Workman Ditch.....	30
		Puente Mill Ditch.....	60
		Pio Pico Ditch.....	160
	Middle San Gabriel...	Peck Ditch.....	(?)
ſabriel and San ıando group (4).	Cañon and springs supply.	Millard Cañon Water Company	50
		North Pasadena Irrigation Works	(?)
		Arroyo Seco Springs Works.....	500
		Pasadena Lake Vineyard Land and Water Company.	1,000
		Highland Park Water Co. (domestic).....	.....
		Crystal Springs Water Co. (domestic).....	.....

San Fernando Valley irrigations.

ernando Valley p (5); Cañada roup (k).	.....	Cresenta Cañada Colony Works.....	1,900
		Pickens' Cañon Works.....	200
		Hall Cañon Works	230
		Earl Cañon Works.....	100
		Shields Cañon Works	.....
		Verdugo Cañon Springs Works	1,200
	Lejunga and Paicoma Cañon.	Monte Vista Colony Works.....	600
		Phillips' Ditch	17
		Johnson's Ditch.....	5
	San Fernando Cañon..	Porter Land and Water Company's Works.	543
	Mormon Cañon.....	San Fernando Valley Improvement Company.	80

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

LOS ANGELES COUNTY—Continued.

Los Angeles Valley and coast plains irrigations.

			Inside city.	Outside city.	
Los Angeles group (6) The Los Angeles city system.	Los Angeles River	Zanja:			
		6—1	50		50
		1	178	500	678
		2	328	1,500	1,828
		3	532	800	1,332
		4	309	500	809
		5	168	1,500	1,668
		7	398	1,000	1,398
		8	4		4
		8—R	148	2,000	2,148
		C and R	159	100	259
		Nichols	5		5
		9—E	254		254
		9—R	204		204
		Feliz, Chavez	200	150	350
	Total		2,937	8,050	10,987
Irrigated by city sewage					3,000
					13,987

Coast plains irrigations.

Group.	Supplied from.	Name of corporation or ditch.	Irrigated area.
			Acres.
Cahmuga, Ballona group (7).	Ballona Creek	North side Ditch	735
		South side Ditch	800
Lower San Gabriel group (8)	New San Gabriel River	Temple Ditch	350
		Workman Ditch	375
		Rincon Ditch	400
		Cato Ditch	1,300
		Standifer Ditch	1,300
		Banta Ditch	715
		Los Nietos Ditch	950
		Little Lake Ditch	1,000
		Section Line Ditch	500
		Agricultural Ditch	1,000
		New River Ditch	1,000
		Clear Water Colony Ditch (no data)	
	Old San Gabriel River.	Arroyo Ditch, four branches:	
		Sandridge, Stockton, Taylor, Cochran	3,800
		Repetto Ditch	100
		Foster Ditch	480
		San Antonio Ditch	800
		Cerritos Colony Ditch	1,200
		Ryan	430
Lower Santa Ana River group (9).	North side	Anaheim Union Water Company, three canals:	
		Cajou, New Anaheim, Old Anaheim	4,000
		Yorba Ditch	600
	South side	Santa Ana Valley Irrigating Company Canal.	15,500
Santiago Creek group (10).		Serrano and Carpenter Companies:	
		Serrano Water Company	1,300
		Carpenter Water Company	800
San Juan Capistrano group (11).		Old Mexican Ditches:	
		Mission Viejo Ditch	383
		Lower Trabuco Ditch	327
		Upper Trabuco Ditch	40
		Boca de la Playa Ditch	50

EXHIBIT B.—*Actual irrigation, etc.*—Continued.

SUMMARY.

Area irrigated in San Diego County, 1888.

	Acres.
San Diego and San Dieguito Rivers	360
San Luis Rey River	480
San Margurita River	312
San Jacinto River	965
Total	2,117

SUMMARY.

Area irrigated in San Bernardino County, 1888.

	Acres.
Santa Ana River irrigations:	
Santa Ana Cañon:	
Group (1)	4,435
Basin diversion:	
Group (2) Riverside Mesa subgroup (*a*)	7,686
South side Santa Ana subgroup (*b*)	799
Warm Creek subgroup (*c*)	1,353
Lytle Creek and City Creek subgroup (*d*)	384
North side Santa Ana subgroup (*e*)	881
Jurupa Valley group (3)	1,202
Rincon group (4)	933
San Bernardino Valley irrigations:	
South Cañons group (5)	1,466
North Cañons group (6)	1,590
Cucamonga Plains irrigations:	
Cucamonga Plains group (7)	5,361
Total for all groups	26,070

SUMMARY.

Area irrigated in Los Angeles County, 1888.

	Acres.
Cucamonga Plains irrigations:	
Pomona group (1)	5,375
San Gabriel Valley irrigations:	
Sierra Madre Cañons group (2)	
San José subgroup (*a*)	225
San Gabriel River subgroup (*b*)	5,150
Santa Anita River subgroup (*c*)	350
San Pasquel subgroup (*d*)	765
Basin Group (3)	7,590
San Gabriel and San Fernando group (4)	1,550
San Fernando Valley irrigations:	
San Fernando group (5)	4,875
Los Angeles Valley and Coast. Plains irrigations:	
Los Angeles group (6)	13,987
Coast Plains irrigations:	
Cahuenga-Ballona group (7)	1,535
Lower San Gabriel group (8)	15,600
Lower Santa Anita River group (9)	21,000
Santiago Creek group (10)	2,100
San Juan Capistrano group (11)	800
Total for all groups	80,902

FINAL SUMMARY.

Area irrigated in the three lower counties, 1888.

	Acres.
San Diego County	2,117
San Bernardino County	26,070
Los Angeles County	80,902
Grand total	109,089

STATEMENT OF W. S. GREEN, OF COLUSA.

Mr. Chairman and gentlemen, I come from a region of country that will produce 2 per cent. of the wheat of the United States. Therefore, we do not claim to have any arid land in that region. We think, however, that irrigation will benefit us to the extent that we have farmed four districts under the Wright law, and propose to irrigate 300,000 acres of land in that county. And that would be our opinion of irrigating arid lands. After discussion among the people there they have voted in those districts, some four or five to one, in favor of irrigation. Of course, it is their opinion and my opinion that the arid lands can be irrigated to a great benefit. They have no arid lands in that district; but they have voted bonds there to the extent of some million and a half of dollars for the purpose of irrigation, and some of the bonds have been sold. The central district was the first to sell the bonds, the first to have contracts to do work under the law of two years ago, the session of the legislature before the last. After hearing Mr. Hall and after seeing his report, I should say that he has gathered facts to which I can add nothing.

But I should like to say a word on the subject of sanitary conditions of irrigation. I have investigated that question for a great many years, and I believe there is no such thing as malaria in the atmosphere of California; that it is entirely in the water we drink. Where irrigation has made the locality unhealthful, it is because irrigation has simply changed the condition of the water. The atmosphere is all the time in motion, and you can not poison it any more than you can poison the ocean or a stream of running water. It takes too great an amount of poison, and from actual observation—and I have been in the State twenty-five years—I can say that with the same atmosphere and drinking different water some persons will have malaria and some will not. I find that malaria exists in spots. When I commenced to investigate the subject I took several portions of the State and I found that to be true—that malaria exists in spots. But it is not due to irrigation or the want of it. It is in the water that is drank, and those who are careful of the water they drink need not ever have malaria; that is, in this State. I could give a good many instances of that.

The CHAIRMAN. I understand you have given some attention to the subject of the effect on the water supply of cutting timber on the water-shed.

Mr. GREEN. I have not given the matter such attention that I could give to this committee any facts. I think this timber should be protected. That is the result of my observation. But I can not give you any figures. The result of my observation has been that the cutting of timber decreases the rain-fall, and the assembling of timber will make it more precipitous in the valleys. But I am not prepared to give any figures. In fact I was not expected to meet this committee until yesterday, and, therefore, have no figures to present.

I should like to call the attention of this committee to the importance of Congress regulating the taking of water from the navigable streams and their tributaries. There will be some trouble to grow out of that unless it is regulated by Congress. If everybody can say that navigation is affected by it, and can bring suits for taking the water from the streams and tributaries, there will be trouble to grow out of it. That subject is being discussed in our county, and I think it is an important thing for the committee to take into consideration. There should be some authority to say how much water shall be taken away.

STATEMENT OF GEORGE MANUEL, OF FRESNO.

Mr. Chairman and gentlemen, my connection with irrigation was confined to Fresno, Kern, Stanislaus, and San Joaquin Valleys for ten years, and during that time I was continually engaged in letting out the headwaters of the Fresno. The question has been raised as to the economic value of irrigation. I had occasion to investigate that subject a little, and I went to the Board of Trade of Fresno. That board gathered statistics on the subject from the assessor of that county.

In 1870, in township 14 south, range 20 east, sections 1 to 5, assessed to W. S. Chapman, at $1.01 per acre; section 36, at $1.13 per acre; that made an assessed valuation of that township, in 1870, of a little over $25,500 in round figures. In 1880 the Bank of California tract, a portion of these twelve sections, at $4 an acre, and Bank of California tract, 240 acres, at $5 per acre. C. A. Towne, section 2, adjoining Fresno City, at $5 per acre. C. H. Hoffman, section 12, near Fresno, at $5 per acre. E. Jansen, six sections near Fresno City, at $4 per acre. In 1888, A. T. Covell, in Washington Colony, 5 miles from Fresno, 60 acres, at $150 per acre. Sections 1 and 2 and 11 and 12 at $250 to $300 per acre, $250 per acre being about the average for unimproved land. And this increase in the value of land is due to irrigation. It is the same land exactly, only in different years, as irrigation has progressed.

Sections 6 and 7, at $100 per acre; section 19, at $75 per acre; sections 5 to 8, unimproved, and from one-half to 1 mile from the city of Fresno, at $125 and $200 per acre; sections 17, 18, and 19, averaging $85 an acre, and sections 23, 24, 25, and 26, at $75 per acre. That is the valuation of that township. The first assessment was $25,500 in round numbers, and the last assessment of the city, $6,800,000. And the total valuation of that township is probably in the neighborhood of $9,000,000.

The CHAIRMAN. That is the assessed value of the land?

Mr. MANUEL. Yes; of course the town property is in that township.

The CHAIRMAN. Would there be any town there if it were not for irrigation?

Mr. MANUEL. We will compare it with Berendo, which was started about the same time, and now consists of a shop and one hotel. Fresno has 12,000 inhabitants. The assessed value of the property in Berendo is a few thousand dollars, and it has no irrigation. The value of the property in Fresno County is due to three or four canals coming out of the north side of the Kings River. And so it is at Hanford.

The CHAIRMAN. What is the result at Hanford?

Mr. MANUEL. Hanford has increased largely. I do not know that it has increased as fast as Fresno, but the values are somewhat in proportion. Concerning the value of irrigation, I know of one canal that was said to cost in the neighborhood of $50,000. The first year after its inception the increased value of the real estate along the line of the canal was $640,000—land that could before have been bought at $2.50 per acre had increased in value sufficient to make that valuation. So I could give other instances, but I suppose that would be sufficient.

Now, concerning the value of this governmental investigation, what interest will it be? I am the engineer of this Fresno canal, and I was the engineer of the Madora district, lying immediately north of the San Joaquin River, also the West Side district, which comprises a long strip of country in some five counties from Fresno to San Joaquin, and containing about 260,000 acres of land; and of the Turlock district, lying

in Stanislaus County. The people in that section voted $850,000 of bonds, and one item of that $850,000 was $140,000 for purpose of making storage reservoirs. Any work that this committee or the Government may see fit to do in that direction will be utilized by these parties. So in these other districts, they will probably avail themselves of any surveys that are made, and will proceed immediately as soon as they can place their bonds to carry the work to completion.

The CHAIRMAN. Are the places in that district for reservoirs in the hands of private parties, or are they public lands?

Mr. MANUEL. I think they are public lands.

The CHAIRMAN. Then the reservation of those sites would be an advantage?

Mr. MANUEL. I think so.

Mr. MILLS. How much would it cost per acre to get the water onto the land?

Mr. MANUEL. Probably that question can be answered by saying that we sell our water now for $5 per acre—we give a water right for that.

Senator JONES. Does the user have an annual payment to make after that?

Mr. MANUEL. One hundred dollars. But the water right, the taking of that water onto the land, leaving a marginal profit to the ditch company, is $5 per acre. We are irrigating 40,000 to 50,000 acres of land, and yet we are filling up as much more without pay.

As to the duty of water. Of course Fresno is peculiarly situated in some respects, and we have a large quantity of water which we use very liberally, and we do not consider it lost. The liberal way in which we use water benefits a population 10 miles away, on whose land big wheat crops are produced.

Senator JONES. Land which was not productive until this water was turned onto it?

Mr. MANUEL. Yes. They could not raise a bean. That is the result of irrigation, not due to direct contact with the ditches, but the filling up of the country. We have adopted the policy of encouraging irrigators to use all the water they can. When there is a shortage of water, of course it is different; but when there is 10,000 feet of water going to waste and benefiting no one, we encourage them to use it.

The CHAIRMAN. Is there water enough in the San Joaquin Valley to irrigate all the land in the valley if it were properly stored?

Mr. MANUEL. That is a large question. I will state that from Kings River north the water coming down is ample to irrigate all those lands; but from Kings River south it is impossible to irrigate all the land. You will find that as you go north, say from Kern River, the precipitation and the amount of water running in the streams gradually increases in a certain ratio, so that the northern part of the State is much better supplied than the southern part. Take the Kern River. There is a larger body of land attached to it than anywhere in the valley; but it has not the body of water that other rivers have. To illustrate that. We think that the Kern River has a drainage of 2,300 miles, and the Mokelumne has a drainage of 2,600 and the Mokelumne has a greater flow. But if you go farther north, a river of 600 miles of drainage supplies more water than the one of 2,300. It increases in that proportion. So that the most crying need for saving water is in the southern portion of the valley, and the farther you go south the greater the need. In Fresno Valley we have between the San Joaquin and Kings rivers *1,260 square* miles.

Senator STANFORD. Did you ever make any estimate of what it would cost to irrigate by pumping on a large scale?

Mr. MANUEL. Yes. Probably these district will furnish a basis. For instance, the Turlock district. For the area of that district, a little over 200,000 acres, $600,000 of bonds were voted. In other words, nearly $3 per acre. That is according to the best estimate that we have made. That would be ample to construct every branch ditch and to carry water to every alternate section. That is the cost. The Madeira district, with 300,000 acres, the bonds voted were $850,000, nearly the same proportion. Of that $850,000, $140,000 were intended for storage reservoirs. The west side is not in a condition that will permit of figures; but it is somewhere in the neighborhood of $5 or $6 an acre.

The CHAIRMAN. Was the voting of bonds based on mere estimates or the actual cost?

Mr. MANUEL. Mere estimates.

The CHAIRMAN. You have stated that you have investigated the question of pumping.

Mr. MANUEL. I could give you some figures on that subject; but of course that is a scheme which we do not much employ in our country. Our water supply is abundant, and we have not gone into that.

The CHAIRMAN. You think you can get water enough without it?

Mr. MANUEL. We could get it; but we depend on the gravity supply. What we want is a storage system to help out our low water. For instance, about six or seven months of the year the rivers flow large quantities of water, enough to supply all the canals; but commencing about July or August, until the first of December, the supply is short; that is to say, the rivers run down. While we can get along without that help, while it is not a necessity, yet it would be a convenience. I think water during that period would be a convenience, and it is a necessity for young orchards, but not a necessity for anything else.

Now about malaria at Fresno. When I went there I weighed 150 pounds, and people told me that I would die if I went there. But I have been there surveying ditches, and you see the result.

Mr. CHIPMAN. What is your present weight?

Mr. MANUEL. Two hundred and twenty pounds. I attribute it to malaria in the system! But, seriously, I would say that I have a report on the subject of irrigation and its tendency to produce malaria. The British Government in India appointed a commission to visit Italy and investigate the subject there; and that commission labored for five years. That commission reported that proper irrigation did not produce malaria, but improper irrigation would. They also made some proposition about the construction of canals and works which they stated would be effectual to prevent malaria; and experience has shown them to be effectual.

The CHAIRMAN. Did that relate to drainage or the formation of the canal?

Mr. MANUEL. Both. In making canals you should not leave holes for stagnant water to accumulate. That commission came to the conclusion that running water in canals did not produce malaria, but that improper irrigation, where the water was permitted to run into ponds and swamps, did. There was also a British commission that came to this country and took the testimony of the people of Fresno and of those lower counties. That was a royal commission, sent from Victoria. But all I know is from personal experience, and all I say is that proper irrigation will not *produce malaria*.

And in regard to the subject of increase of rain-fall on account of irrigation, all I know of that subject is from precipitation tables in Fresno and the surrounding country. I see that the rain-fall there has increased from a half to a third, that is to say, from 6 inches up to 8 and 12 inches. That is, in the last four or five years. But whether that is due to irrigation or simply a coincidence, I do not know.

Then about crops at Fresno. The time was when a certain country lying east of the canals produced only about one crop in three or four. Now, it produces nearly every crop; it is seldom that any crop fails. The amount of crops produced certainly has been increased, and the failures have been reduced one-half. That is not due to irrigation direct, but from the fact that the land is in the track of the wind from the irrigated country around.

The CHAIRMAN. You think it is due to the wind in a moist country as it does not dry up so much.

Mr. MANUEL. That seems to be the general impression, and I think the correct one.

STATEMENT OF L. M. HOLT, OF SAN BERNARDINO.

Mr. Chairman and gentlemen, there are many points to be referred to in connection with this subject; but there was one suggestion made by Mr. Hall which, while practically true, tends to mislead the committee, and that is with regard to the duty of water at Riverside and other southern counties. I have lived at Riverside for ten years until last year. Now I am living at San Bernardino, close by there. I have kept watch of the water at Riverside with a view to studying it in connection with the new canals. It is true, when we take into consideration the amount of water that runs into the canal and compare it with the number of acres of land irrigated, Mr. Hall's statement is practically correct. But when we take into consideration the amount of water that is sold by the company or dealt out by the canals to the land owners, we find a different state of affairs. I took one of the Riverside companies from its formation up to 1870 and compared the number of inches sold by that company and paid for by the users with the number of acres of land under cultivation, and up to that time there had been no year where the consumer had used to exceed an inch of water to 5 acres of land.

But there is a waste of water in the main canals, and the hundreds of distributing ditches. For instance, take the ditch on which my orchard is located. They turn off 60 inches of water from the main canal and get 20 inches to my orchard. This shows a waste of water in the system of distribution, and not the amount of water that was actually needed to put on the orchard. When it comes to the use of water in other sections of California, I will state that a great deal depends on the location of the water system—its proximity to the coast. For instance, at Pasadena they started with a system of an inch to 160 acres, and the supply was increased to an inch of water to 60 acres.

Riverside is different from any other section down there so far as water is concerned. The Gage system about Riverside is founded on 1 inch of water to 5 acres, and it does not matter how much they may want, that is all they are going to get. At Fresno it is an inch of water to 8 acres. This was afterwards increased so that they could get an inch of water to 4 acres. The Pomona system was an inch of *water to 10* acres. Whether that is enough or not, they have been suc-

cessful there; but that is all they can get. The Ontario system is 1 inch of water to 10 acres, and that is all they can get unless they can get another supply of water; but they have been successful There is land in the irrigation system which is entitled to water, but it can not get it. In the Etiwanda system they have 1 inch of water to 8 acres. If I was rightly informed, Etiwanda furnishes some of the largest raisins in California—the largest grapes, so far as raisins are concerned. And I was told that they did not need the water that they had. I have given these facts just as I got them. I may be misinformed about some; but I guess I am pretty nearly right. Some require more irrigation than others. Those back from the coast require more than they do down by the coast. While Pasadena has very little water, there is a vast difference between an inch to 60 acres and an inch to 160 acres; but a large number of their crops do not need irrigation at all.

The CHAIRMAN. Can you tell to what extent the people of those districts have taken up the water supply?

Mr. HOLT. Pasadena is pumping its water. They lift it somewhere in the neighborhood of 100 feet. The other systems, with the exception of Redland, I do not think have increased their water supply. They have increased the supply of water with a view to spreading the acreage.

The CHAIRMAN. How do they do that?

Mr. HOLT. By means of artesian wells, by tunnels, and by reservoirs. The Ontario system runs a tunnel up the bed of the cañon, under the water supply, and I think the tunnel is in the neighborhood of 80 feet below the surface of the stream. But the results of that tunnel have not been very satisfactory as yet. They have now struck bed rock, and they expect when they cross cut to get a large supply of water. It has not been satisfactory as yet, though they have had as high as 75 or 80 inches of water in their tunnel at times. But it has less now.

With regard to the value of the land without irrigation, I would say that the tract of land on which Riverside is located twenty years ago was assessed at 75 cents an acre, and the owner appeared before the State board of equalization to have that estimate reduced. I do not know that I could give the assessed value per acre all the way through of that land at the present time, but the 6,000 acres is valued at a little over $4,000,000, including the town site. The actual value of the orchards and vineyards in Riverside will to-day stand at about $1,000 or $1,500 per acre. The production of that 6,000 acres at Riverside last year was 1,000 car-loads of oranges and 200,000 boxes of raisins, the two items covering 4,000 acres of land—3,000 of oranges and 1,000 of grapes—20 pounds in a box. The other 2,000 acres of the settlement was devoted to other fruits, and I could not give the figures with regard to them. The oranges on the tree sold for from $1.50 to $3 per box, and there were 300,000 boxes. The highest that we have received there on any acre up to the present time has been $1,100. Some of our orange trees as yet are not bearing.

The CHAIRMAN. Was that $1,100 for one crop?

Mr. HOLT. Yes; the highest received for any one orchard in San Bernardino County has been $1,750 for one crop on an acre and a quarter. The population of Riverside on the 6,000 acres to-day is about 7,000.

Mr. ESTEE. What was the population of Riverside before irrigation was practiced there?

Mr. HOLT. We had one sheep herder before that.

Mr. CHIPMAN. Does *irrigation* affect the healthfulness of the community?

Mr. HOLT. It does not, so far as malaria is concerned. I agree with some that the quality of water may not have been so good, on account of ditching their water. Since they have piped their water the healthfulness of the community has been good. The question has been asked whether this country filled up as it did in Fresno. There is no place in California where they have gotten the same results. It was 40 or 50 feet to surface water when it was established, and it is the same now.

The CHAIRMAN. Is it on a sub-soil?

Mr. HOLT. No; it is on a meadow, and the meadow is below. All the surplus water goes down into the river and does not fill up at all. One of the main sources of supply there is the artesian well.

We have a peculiar formation around San Bernardino which we would like to point out. There is a dike, and above that dike is the artesian basin, and you can sink a well to almost any distance and you would hardly get surface water, and it is only about 2 rods from the artesian belt that you can not get artesian water. From that artesian belt we are getting our water supply for our Gage system. He has two hundred wells there on an average of 200 feet in depth, and they give 200 inches of water. He has one well there that gives 200 inches of water single flow. It is the largest well in the valley.

The CHAIRMAN. Has the supply of the wells been reduced by multiplying them in number?

Mr. HOLT. It does not appear to have that effect, or has not yet. The flow at this season of the year on the outer edge of the stream has decreased, and in some places entirely ceased, and has heretofore during the summer season. But when the winter comes on again they flow. I do not know that we have any permanent decrease in the flow of water in those wells since they were sunk. Mr. Gage in his system has in the neighborhood of 1,700 inches of water.

Senator JONES. Miner's inches?

Mr. HOLT. Yes; fifty of these inches make a cubic foot per second. So far as artesian wells in the southern portion of California are concerned—the other sections I can not speak of—there has been no permanent reduction in the flow. There is a variation every year; there will be less water in the summer time and more in the winter.

Senator JONES. How far is the artesian district in California?

Mr. HOLT. We have several. The San Bernardino district will cover about a township—thirty-six sections.

Senator JONES. How many wells are in that township?

Mr. HOLT. Five hundred wells. I think fully that many.

Senator JONES. Is the flow now as good as it was when the first well was sunk? Has there been any decrease in the flow of the first well on account of the sinking of the other wells?

Mr. HOLT. No; unless it may be in the summer time. But in the winter it will go up to the standard again.

Senator JONES. Do you know from where the water comes?

Mr. HOLT. Some have the theory that it comes from the mountains or the Mohjave Desert.

The CHAIRMAN. What district is covered by the reservoir?

Mr. HOLT. It includes Redland, Highlands, Riverside, and even west through to Rialto. It has not been taken through there.

The CHAIRMAN. Can you describe the work and its success?

Mr. HOLT. I will state that the company has made an arrangement to put in a new dam 120 feet high instead of the present one, which is only 24 feet high. When they do that they will have a supply of water *that will give them* 20,000 inches of water during the season.

There are other sites there. I went over to San Bernardino, over the ridge, to see a reservoir site. The reservoir when made will irrigate 10,000 acres of land, and it will cost in the neighborhood of $75,000 to complete the reservoir and take the water through the land to be irrigated. The man who applied for a reduction of the assessment on his land from 75 cents an acre ought to have had this land. The theory is that they can run stock on that land, but it will be a very precarious business. There is no value to the land except it may be a speculative value, and the speculative value is how much is it worth to buy it and put water on to it. You can not raise barley there to make it pay except it may be on moist lands.

There are 250,000 acres of land in San Jacinto Valley, in San Diego County. The Hemet Valley is another valley similar to the Bear Valley. They have all their surveys made and are ready to dam in. They estimate that when the dam shall have been completed they can irrigate 100,000 acres of land in that valley.

The CHAIRMAN. Will surveys by the Government and the reservation of the public land be of any service to you in carrying out these projects?

Mr. HOLT. I think the reservoir sites in southern California, so far as irrigating between the mountains and the sea is concerned, are all taken up.

STATEMENT OF WILLIAM COLLIER.

Mr. Chairman and gentlemen, I have not had enough experience in the States, but I have always had a belief that timber ought to be protected in order to protect the rain-fall. I made a trip on the mountains the other day, and I saw large tracts of timber where the timber had been cut away. New timber is a better protection to rain-fall than the old growth, and the ground was covered with a thicket from 12 to 50 feet high. But whether all timber lands send up the new growth in that way or not I do not know. If they do not, I say keep the timber there.

STATEMENT OF R. B. BLOWERS.

Mr. Chairman and gentlemen, I live under an irrigating system of about 30,000 acres under the Moor Ditch. Clear Lake covers about 300,000 acres of land, but only a small portion of that has been used. In the early days we paid for water on our wheat land, but at the present time it is used for alfalfa and agricultural purposes. In my neighborhood we consider that one-half a cubic foot per acre put on during the whole season (1 cubic foot is the maximum) is sufficient for a vineyard, and is sufficient for a variety of horticultural products. Our system is a charge of $4 for every cubic foot of water.

The CHAIRMAN. A cubic foot per second.

Dr. BLOWERS. We get probably from 1½ to 2. It is not measured. We get a liberal supply because we have a liberal supply to draw from in the ordinary irrigating part of the season. In the summer and in the drier seasons our supply fails, because there are underground streams that take it from our system and distribute it all over the country. If we had Clear Lake during the summer and sufficient drainage for all these 300,000 acres under the Moor Ditch and between Clear Lake and Cache Creek and Putah Creek, a large area of land in Cashe County and land on the top of the mountains more favorably situated on account of their natural *grade than any* other land in the world, could be re-

claimed. If we had plenty of water we would probably use on alfalfa a foot per acre; or, in other words, we would pay $3 an acre for three or four irrigations. With that result in water and the proper amount of irrigation to keep the gophers off, we could insure 10 tons of alfalfa hay to the acre for ten years from the seeding, each of those tons representing 100 pounds of neat flesh put on to cattle.

In regard to climatic conditions. If all the upper part of the Sacramento Valley which includes Tehama, Colusa, Yolo, and Solano Counties were irrigated it would have its effect on the climate. It would reduce the evaporation of this vast amount of water, would reduce the temperature, and consequently raise the dew point to a higher degree. And it would deprive the hot desiccating north winds with which we are troubled of their effect, and would change the climate materially to our benefit in that manner.

With regard to our country being arid I will say that it is arid as compared with the condition in which we can place it by intelligent irrigation. We are now pumping water from Cache and Putah Creeks, and there are suits for damages that have been instituted against several parties for pumping water from Putah Creek. But, speaking of the temperature, I will say that there is much more rain in the San Joaquin Valley now than there was twenty years ago, and it will continue to increase so long as the area of irrigation is increased.

Mr. MILLS. What interest will the hay pay?

Dr. BLOWERS. That depends. If a party should raise it for beef-cattle alone 1 ton of that hay would be equivalent to 120 pounds of beef. Beef is 5 cents a pound. Therefore the gross amount of produce from each ton would be $6 per ton, and the gross amount of the product that would go into the products of the country would be $60 an acre.

Mr. MILLS. That would be 10 per cent. on $600.

Dr. BLOWERS. Of course the element of labor would have to come out of that. Irrigation allows us to raise any kind of product that we are desirous of producing. We can raise any product that can be raised in the temperate zone.

The CHAIRMAN. What would be a fair-sized farm of irrigated land for a farmer to irrigate himself?

Dr. BLOWERS. That would depend on the number of children he had. I have a neighbor who has one child. That child married and has children. He had 10 acres of land and 5 acres were bearing. He was a bricklayer and he hired help, and kept an account of the net proceeds of those 5 acres in raising grain, and they amounted to $1,000 a year for several years. That is to say, he made a clear profit of $200 per acre. I suppose his last success of that kind was three or four years ago. Every square section of land in Yolo County under irrigation could support a population of 1,000 souls.

The CHAIRMAN. With an ordinary family would 40 acres be enough?

Dr. BLOWERS. They would have to hire about $2,000 worth of labor to get along. I have paid on 25 acres, a raisin vineyard, $5,000 for unskilled labor. I paid in freight on the product of a single acre of irrigated land $1,000, and I have shipped 10 tons of raisins from 1 acre. We have to run our risk. We do not always know how our fruit is going to get to market.

Mr. CHIPMAN. The committee may not be aware of the desiccating effects of the north wind, which results, sometimes, in making the grain fields dry in two or three days, and in the destruction of the wheat crop. *That north* wind originates in the desert east of the Sierras. I would *like the doctor* to tell whether irrigation would destroy the effect of that *north wind.*

Dr. BLOWERS. The returning polar wind, the wind that once went upward from the torrid region, sucks its way back to where it starts, that is to the torrid zone. Whenever the wind is sufficient to send a large body of air to the south, it has a tendency to bring toward the earth this polar current; and my idea is that if the arid region of Arizona and California—the whole surface of that country—were covered with vegetation, the effect of these intensely hot winds would disappear. The temperature would be reduced to such a degree and the moisture increased to such a degree that they would not have the desiccating effect of which so much complaint has been made.

STATEMENT OF E. B. PERRIN.

Mr. Chairman and gentlemen, I have been connected with irrigation for fifteen years, and I have given it a good deal of thought, as a physician. Here I have a Government report, the census report of 1870, published by act of Congress, and it is about as impartial and as perfect a report as can be gotten. It is better than individual estimates. Now, I think Mr. Hall fell into a mistake that is calculated to do harm.

Take our Fresno country—and all California can take a shot at it—and we have done there what the world has never done before in the way of getting productions from the ground. While Los Angeles has given 5 and 6 tons of grapes, and Napa 5 and 6 tons, in Fresno we make 20 and more; but we will stop at 20.

Mr. ESTEE. Not as a regular thing.

Mr. PERRIN. No, not as a regular thing. I say what we will do. I have been told by my friends that they have sold 28 tons to the acre. On the question of health, you will find that Sacramento Valley has three out of five of malaria, San Francisco one out of five, Los Angeles one out of five, and this terrible Fresno one out of five. That was in 1870.

Senator JONES. Before irrigation?

Mr. PERRIN. Before very much irrigation had been practiced there. Now, since irrigation we claim that it has made that country far more healthful, and it is more healthful for the animal than the man, for this reason: They have better water to drink. They have artesian water now and good drainage. In regard to consumption, which our western friends ought to know, and which the people of the United States ought to know, there are the reports on consumption. They show Boston 5, Chicago 4, San Francisco 4, Mobile 5, Los Angeles 3, San Diego 1, and Fresno none.

Mr. ESTEE. That was in 1870.

Mr. PERRIN. Yes; but you must remember Fresno had a population in those days. Take the bowel affections and typhus fever. We have a wonderfully healthful country. While San Francisco has more trouble with the lungs, it is free from malaria.

Mr. ESTEE. I wish you would show the effect that irrigation has on the human system anywhere. State what its effect is so far as causing malaria is concerned.

Mr. PERRIN. I would not have made these remarks but for what my friend, Mr. Hall, said, which is calculated to do harm. Of course, if you put water on the land and the people drink the water from the ditches, it will have a bad effect, but if you have good drinking water and proper drainage, not only the men but the animals will be healthy.

It is not only that. *To show* Mr. Estee that I am right in this I will

say that if he will go to certain portions of Fresno County, where cattle have died for years, he will find that the people can show him a simple way of stopping cattle from dying—that is to give them good water. Mr. Carr, of Kern County, who is largely interested in irrigation there, told me that he would not give his cattle any water after this that he would not drink himself. As soon as people understand that cattle as well as people must have pure water to drink we will solve a good many difficulties.

Mr. ESTEE. Professor Hilgard, of the University of California, is here, and would like to be heard.

The CHAIRMAN. We shall be glad to hear Mr. Hilgard.

STATEMENT OF E. W. HILGARD, PROFESSOR IN THE UNIVERSITY OF CALIFORNIA.

The CHAIRMAN. The committee will be glad to hear anything that you may have to say on the subject of irrigation in California or elsewhere.

Mr. HILGARD. Our experience in irrigation in California is precisely in the line of the gentleman who has spoken before me. As professor of agriculture in the State university, and now in charge of the experimental stations of the State, I have come in contact largely with irrigation, and so far as experiences have gone, in regard to the effects of irrigation, I can only say that I am fully and entirely in accord with everything that has been stated with regard to the increased value and the wonderful effects which the water produces, even in regions which have rain-fall. I have naturally been led to study rather the natures of soils and their origin than the economic questions involved. In regard to the nature of soils which can be irrigated in this State, I would say that I have yet to meet the soil that can not be reclaimed by irrigation.

At one time, by the courtesy of the Central Pacific road, I had a complete set of samples of soils from the places along the road, all the way through its line. I have examined all the soils, from an agricultural stand-point, and, with a single exception, there was not one that could not be cultivated by irrigation. As a desert, the Mojave may be said hardly to exist. It is purely a question of water. The part of the desert that has been irrigated amply proves that fact.

In regard to the water supply, I have made some study which impresses me most strongly with the great importance of this topic of reservoirs. In the first place, the water supply, undoubtedly, in most portions of the State, is hardly adequate to give a supply for irrigation in the dry season. In the second place, a great many lands will be benefited by irrigation which are now cultivated by other means.

Senator JONES. When you state that the water supply was not sufficient, do you mean that it is not sufficient without storage, or that it is not sufficient with storage?

Mr. HILGARD. I meant that it is not sufficient without storage. In the foot-hills this state of things exists: A large portion of the land can be cultivated without irrigation, but in a large portion of it a good deal of the soil is shallow, although in other respects it is first-class. With irrigation it can be settled; without it the crops will not be certain, and therefore the lands will not be settled so soon.

There is one point of importance I should mention, and that is the *quality of the* water for irrigation. In regard to storage reservoirs,

which are naturally available, perhaps one of the earliest that has been spoken of has been Tulare Lake. When this enterprise of irrigating the San Joaquin Valley with the waters of Tulare Lake was first broached, I learned (having been then only a short time in the State) that the water was likely not to be suitable for irrigation. I had a sample of the water procured and found that it was strongly alkaline. I have since continued that study, and I believe that the water at the present time would not only be unsuitable for irrigation, but would be detrimental to any land on which it was placed. Three enterprises have been successively started in utilizing land in that neighborhood. I was instrumental in calling attention to them. From the study I have made I am strongly inclined to think that the water is not even adapted for storage. At present the very bed of the lake, I believe, is charged with evaporated strata of alkaline salts, which would make it entirely unadapted for irrigation unless the alkali were washed out. This question is of great importance to the country. Similar studies should be made in other directions. You have heard that artesian wells would give water for irrigation. A very large portion of these wells would give very good water for that purpose. Another portion would give water entirely unfit for that purpose, and the Government alone has the ability and the means of making that study complete.

I know of one series of wells in San Joaquin Valley that have done considerable damage in the irrigation of lands, and I think it highly expedient that this study should be undertaken for the purpose not only of finding the waters which can be used for storage, and the storage reservoirs themselves which can be utilized, but also those which can not be utilized for reasons not generally understood by the people.

There is another branch of the subject which I have studied. That is the connection of irrigation with the alkali. Of course you know that alkali, that is, soluble salts, are to some extent in the arid regions, including in that term the country west of the one hundredth meridian. The presence of this natural alkali is the natural result of the deficiency of the rain-fall—enough rain not falling to take away the alkali, which is a natural deposit, you may say, of the soil. In Tulare and Kern Counties, the rain-fall being from 6 to 4 inches, not enough water falls at one time to wet the soil more than to the depth of 3 or 4 inches. The evaporations from the surface afterward will bring up all the soluble salts. Those salts will rise to the surface, and will tend to kill the vegetation that might accumulate there. It is a curious result of irrigation in some places that those salts have been brought to the surface. It is necessary that some means of preventing this should be devised, and also some means to stop the further use of alkaline waters in irrigation.

I have in my studies tried to perform some of the duties which will now fall to the Geological Survey to perform. I can only say that the task which is before it in the way of work to be done is of the greatest importance. The means at the command of the State University, or of the experimental stations, are altogether too limited to permit of all these important studies being carried on properly here.

I have set forth these studies in the publication which forms part of my annual report, and of which I present a copy with an abstract to the committee. (See Exhibit C.)

I have also made a study in part of the question of water supply, particularly in the southern region.

The chairman asked a while ago of one of the other gentlemen (Mr. Holt) a question as to where the supply of artesian water came from.

I think the simple reply to that question is that the storage of that water is in an enormous gravel-bed at probably the depth of a thousand feet or more, and that this gravel bed is annually charged with the winter waters of the Santa Ana and other rivers, and if these rivers flow in at the height of 700 or 1,000 feet above the level of the valleys below, of course sufficient pressure accumulates.

With regard to the diminution of supply by boring more wells, this state of facts exists in that region that wells bored quite closely together fail to influence each other to any perceptible extent. In the places I have studied, it is found that the artesian supply is so great that the limits are hard to estimate, except perhaps by the area of the basin, which is about 10 miles by 14 miles, the gravel-bed reaching to an unknown depth. Of course that valley must contain an enormous mass of water.

Mr. MILLS. The artesian system, which constitutes the source of supply there, is peculiar to that region?

Mr. HILGARD. Yes.

Mr. ESTEE. The same influences do not operate upon Santa Clara at all, do they?

Mr. HILGARD. No.

Mr. MILLS. They do not apply to any other region of the State. Artesian water is not to be relied on, in the experience of this country, for irrigation. Storage is the only thing that will add to our water for that purpose.

The CHAIRMAN. Except in this locality.

Mr. MILLS. Yes.

Mr. HILGARD. I was going to say that the communication between the wells in Santa Clara County is freer than in San Barnardino County. In the last few years in which the wells have been specially studied the supply has been getting low, and contiguous wells have unquestionably influenced others very considerably. The supply also has been comparatively limited, and for irrigation purposes have hardly come into consideration at all. Storage would be the only means available.

The CHAIRMAN. You were not there when they first commenced boring wells, were you?

Mr. HILGARD. No, but I know how the wells have run. It is quite peculiar to San Barnardino County.

Mr. MILLS. As to the diversity of agriculture and horticulture, how would they be affected in this State by the artificial application of water?

Mr. HILGARD. The introduction of irrigation in certain districts has simply changed the face of the country from that of a single industry to that of a garden. That is the case more prominently, perhaps, in the San Barnardino Valley. The diversity I consider as one of the prime conditions of prosperity of a community. Any community which pursues one single industry will be likely to be c[illegible] in some unpleasant condition at some time. I was speaking w[illegible] tleman once who told me how very abundant cotton was in [illegible] ut said he, that very time we had nothing to [illegible] thing in occur and has occurred here in resp[illegible] nots

Mr. MILLS. [illegible] the regularity of year by yea[illegible] ve you to [illegible]

Mr. HILG[illegible] ree irri[illegible] something ti[illegible] h[illegible] tailed exami[illegible] which I thin[illegible]

vator to a certain extent of the necessity of fertilizing. A great deal of our irrigation water contains so much potash that the bringing of it from somewhere else is out of the question. In the waters of Riverside the annual supply of one-fifth of an inch to the acre, or 1 inch to 5 acres, is ample for wheat, which takes a great deal. In the San Joaquin Valley, waters are flowing which contain not only much potash, but acid, which becomes a complete fertilizer, and makes any other fertilizer unnecessary. The influence of this item it is impossible to estimate without a detailed examination of the waters; but it certainly is an exceedingly important thing.

The CHAIRMAN. What is the effect of the sediment which comes down in suspension in the waters?

Mr. HILGARD. The sediment almost always contains the finest ingredients of the water. All the deposits brought down by irrigation waters are extremely desirable and add very much to the fertility of the soil; in fact they help it almost indefinitely.

The CHAIRMAN. What do you say as to the fertility of water stored in reservoirs? Is there not organic matter in that that will be a benefit to plant life?

Mr. HILGARD. What accumulates in reservoirs beyond what the water brings into them is hardly worth considering, but the storage will help us to collect what now runs into the sea, not only the water, but, as well, the different materials for fertilizing that it may bring along.

I should like to say a word about the irrigation at Fresno; that is, as to the percolation of the water. It appears to me that it is absolutely essential that some restriction should be imposed from some source in regard to the seepage of the ditches. There is an enormous loss of irrigation water caused by imperfectly constructed ditches. That is one of the points that has not received sufficient consideration. In the case of Fresno it caused almost the ruin of the early settlers, now drowned out by the high-line ditches. Of course, however healthy the climate may be, as soon as water oozes out around every vine, as in the lower portions of the Fresno region, it is impossible that the country should be healthful. What power should regulate these matters I do not know, but the enormous seepage now taking place in the Fresno region is serious.

The estimates made farther south are more reliable. I was surprised to hear Dr. Blowers say that it required 50 miner's inches to the acre to irrigate. A cubic foot per second is equal to 50 miner's inches. That is so much in excess of what is used elsewhere that I should not like to have it stand on record without some qualification.

Dr. BLOWERS. I did not say that. I said that one-half of a cubic foot, running for twenty-four hours, is equivalent to the entire irrigation necessary for the year. That was simply the equivalent of 1 cubic foot per acre for the year; and that was the most successful irrigation performed there.

Senator JONES. I certainly understood the remark as Professor Hilgard did. I do not now understand what is meant by half a cubic foot running for a length of time.

Dr. BLOWERS. Half a cubic foot to the second of time running for twenty-four hours.

Mr. MILLS. They irrigate there but one day in the year. What Dr. Blowers means is that half a cubic foot per second for twenty-four hours answers for a whole year; but they irrigate once in the winter and a little in the spring.

Mr. ESTEE. That is about 4 or 5 inches, professor, is it not?

Mr. HILGARD. Yes. I noticed that some others understood it in the way I understood it, and I desired to have the doctor's statement corrected, if I understood it correctly. Such a quantity of water is, of course, entirely in excess.

Mr. MILLS. They misunderstood it because the ordinary conception of irrigation is that it is a constant and perpetual flow. As matter of fact, people only irrigate once in the winter and a little in the spring. That is all the irrigation needed for a year.

Mr. HILGARD. It has been frequently stated that fruit grown with irrigation is not as good as fruit grown without irrigation. I think that statement is calculated to do damage. I will state this, as a general proposition, that with proper irrigation fruit is improved in the arid regions; with improper irrigation, on the other hand, fruit is ruined and so is the land. There are very few regions of the country that are not benefited by irrigation.

Mr. ESTEE. Have you not found irrigated districts in California where they made raisins a specialty, and is it not true that the raisin grape raised there carries quite as much sugar as any raisin in the world?

Mr. HILGARD. Certainly.

Mr. ESTEE. And is not that the test of the raisin?

Mr. HILGARD. Certainly. If the irrigation is properly done it does not decrease the sugar; if improperly done it may bring it down to a very low degree. In Fresno, where irrigation has been overdone a little, in some places it is known that upon the old irrigated vineyards a ditch 7 feet deep is a very successful corrective of excessive irrigation.

EXHIBIT C.

ABSTRACT OF THE PAMPHLETS FURNISHED BY PROF. E. W. HILGARD, DIRECTOR OF THE UNITED STATES EXPERIMENTAL STATION, CALIFORNIA.

The pamphlet report on "Alkali Lands—Irrigation and Drainage in their Mutual Relations," published as part of the report of the College of Agriculture of the University of California for 1886, by Prof. E. W. Hilgard, treats of the occurrence of lands surcharged with alkali salts in the State of California, of the remedies that may be used in order to insure immunity from the effects of the corrosive salts on growing crops, and especially of the effects of irrigation on alkali lands.

After showing that deficient rain-fall, by failing to leach out the soluble salts formed by atmospheric action in *all* soils, is the necessary cause of "alkali;" that it is the accumulation of the salts on the surface by evaporation of the soil moisture holding them in solution that does the damage to crops, by corrosion of the root crowns, and not the direct action of soil water upon the roots themselves, Professor Hilgard discusses and illustrates by analytical examples, the unfavorable effects produced by alkaline carbonates upon the tillableness of clay soils, which in some cases are rendered wholly incapable of tilth by the presence of carbonate of soda. The dissolution of the humus of the soil by the same substances is an additional injury, causing appearances which have given rise to the popular designation of "black alkali," the most injurious of all. "White alkali," on the other hand, consists of neutral sulphates and chlorodes of the alkalies, and is injurious only when very abundant.

The general remedy for all alkali is leaching of the soil by flooding and underdrainage, thus supplementing the effect of a deficient rain-fall. Deep and frequent tillage, by restraining evaporation, also diminishes the effect of alkali; as also does the shading of the soil. Chemical antidotes can be used in some cases; these must be varied according to the nature of the alkali salts. Gypsum is one of the most important, as it converts the noxious "black" alkali into the relatively bland "white" or neutral compounds, and likewise renders insoluble, and thus causes the retention in the soil, of the humus and soluble phosphates, which are very important to plant nutrition. The action of these antidotes is dependent upon the abundant presence of water, and therefore practically upon irrigation.

A table of analyses, showing the composition of alkali salts from twenty different *points, is* given, showing great variations, and also the fact that the injurious salts are

commonly associated with a large supply of valuable fertilizing materials, so that alkali lands when reclaimed are usually of extraordinary and durable fertility. They also are very retentive of moisture and require less irrigation than non-alkaline ones of the same character.

The effects of irrigation on alkali soils is then discussed, showing that surface irrigation without corresponding drainage is injurious in causing a "rise of the alkali" on lands not previously known to be thus afflicted. In many cases the rise of the bottom water, caused by extended irrigation, has brought alkali to the surface from great depths, and has in California, as in India, rendered large tracts uncultivatable by the increase of the injurious salts. Subirrigation produces this effect to a less degree; but the depths at which water may be applied without actually rising to the surface, so as to be subject to active evaporation, vary in different soils, being least in sandy, greatest in clay soils. Since the prevention of surface evaporation is of fundamental importance, the crops grown on alkali soils should never be broadcast, but always such as admit of cultivation between the rows so as to keep the surface loose; or else, such crops as alfalfa, which by shading the soil and causing evaporation to take place only through their leaves, supplied by their deep-lying roots, also diminish surface evaporation to a minimum. Cereal crops are in general the least suitable; deep-rooted hoed crops, such as roots, castor-bean, and other oil crops, also hemp, ramie, and especially cotton, are recommended for the San Joaquin Valley.

The second part of the report treats of the "Lake and river waters of the great valley (of California) and their quality for irrigation purposes." It is shown by analysis that the lake waters of the valley are much too heavily charged with soluble salts to be applicable to irrigation purposes, and that even their basins would not be suitable as reservoirs for irrigation water on account of the large deposits of alkali salts known to exist in their substrata. As irrigation of the valley lands increases, whatever water drains into these lakes will carry more and more salts into them.

The river waters of the valley are then passed in review and analyses of the same given, showing that they differ considerably in the purity in their summer flow, the Mokelumne and King's Rivers being the purest, while Kern River shows in its composition the origin of the salts now tainting the waters of the lakes fed by it.

The artesian waters of the valley are then discussed, and the fact that in some regions they are altogether unsuitable for irrigation, being too strongly charged with alkali salts, which, however, differ widely in composition; hence detailed investigation of the same is absolutely necessary, as in some cases land irrigated with them would be severely injured.

A third division of the report discusses the experience had in northwest India in respect to the rise of the alkali caused by the establishment of high-lying irrigation canals. The report of a government committee on this subject is presented in abstract, showing that the evils now beginning to be felt in California have their exact counterpart in the experience of India irrigators, only that in the latter case the evils have become so great as to suggest even so extreme a remedy as the lowering of the entire system of irrigation canals, constructed at enormous cost; the alternative being, apparently, their entire abandonment, so far as a corresponding system of drainage can not be applied. Had the latter been kept in view from the outset, a vast amount of costly construction and heavy damage to lands would have been saved. The conclusion reached is that in arid climates *all* irrigation works must provide for drainage, under penalty of causing the ster lization of the irrigated land by alkali; and that the utmost care should be taken to have the irrigation water as free as possible from saline ingredients which, when superadded to the supply already in the soil, will steadily add to the injury.

Another report, issued by the experiment station of the University of California, deals with "examinations of waters, water supply, and related subjects made during the years 1886–'89."

In the first portion of this report are given numerous analyses of well, spring, and artesian waters from various portions of the State of California; also the waters of Carmel and Owen's Rivers used in irrigation. The latter, although flowing through a region heavily charged with alkali, is found not to be overcharged with mineral salts, and perfectly suitable for irrigation purposes.

A somewhat extended treatise on "The water supply of the San Bernardino Valley" gives some data of special interest in respect to possible storage of winter waters apart from reservoirs artificially constructed. A detailed examination of a series of relatively shallow artesian wells bored in the flood plain of the Santa Ana River, a few miles above San Bernardino City, shows the existence of an unu ually abundant store of artesian water in that region, and a remarkable absence of that interdependence of discharge which elsewhere characterizes groups of artesian wells located in close proximity to each other. Searching for the cause of this state of things, it is found that one of the largest streams in the valley—Warm Creek, supplying the irrigation works of the town of Riverside—originates in the level valley, as do a number of copious *springs from* which the water gushes with an apparently

artesian rise, indicating a common source for all these waters within the valley itself, since they issue from unmistakable valley deposits.

An investigation of the geological and hypsometrical features of the San Bernardino Valley, as shown in the wells and in the breaks of the country, proves that the upper portion of the valley trough is filled to great depths and over an area of about 140 square miles with more or less stratified deposits of gravel and bowlders, such as are now discharged from the cañons of the San Bernardino range, and especially from those of the Santa Ana River and Mill Creek. These loosely bedded gravels, interrupted more or less by irregularly disposed water-tight beds, are filled with water under heavy pressure, the difference in altitude from the head of the valley to San Bernardino city being over 1,000 feet in a distance of about 17 miles, while the average thickness of the gravel mass is shown by deep borings to be in the neighborhood of 1,000 feet.

Observation shows that an enormous amount of water must be absorbed during the winter floods, particularly in the upper portion of this great gravel mass, where it is uncovered and composed mostly of large bowlders. Shafts and tunnels excavated near the mouth of the cañons for the purpose of finding unappropriated water have shown the gravel-beds to be dripping with water everywhere; and the suggestion that it would be easy to increase greatly the absorption by loosening the gravel with the aid of lines of blasts judiciously placed, is very forcible. At present an enormous volume of water runs to waste during winter through the channel of the Santa Ana River. If this were diverted upon the gravel surfaces, loosened by blasting, the artesian reserve could doubtless be materially increased, and the flow of the wells in the valley rendered more copious during the dry season. This would be of wider importance than for the San Bernardino Valley alone, for it is almost certain that the original drainage of that valley was toward Los Angeles conjointly with the San Gabriel River, and that the water-bearing gravel-beds extend in that direction, and not along the present course of the Santa Ana River, which passes to seaward through a shallow cañon, in which the bed-rock is exposed. Any addition to or maintenance of the artesian storage at the head of the San Bernardino Valley is therefore of interest to the entire valley of southern California, as it can probably be tapped at proper depths anywhere between the head of the valley and the city of Los Angeles.

The report also gives analyses of the irrigation waters of the San Bernardino Valley, showing that they contain an unusually large proportion of fertilizing mineral ingredients, and that their use will relieve irrigators from the necessity of supplying at least one of the chiefly important crop ingredients—potash—by the purchase of fertilizers, unless production should be very much intensified. Some of the other "cienega" lands of the region are also briefly discussed.

"The Lakes of the San Joaquin Valley" form the subject of discussion in another chapter of the report. The rapid contraction of these lakes by evaporation since the water of the tributary rivers has been largely diverted for irrigation purposes is discussed, and is illustrated by analyses of the waters of these lakes made at successive periods, showing these waters to be utterly unfit for irrigation, although ditches for that purpose have repeatedly been excavated. An examination of the condition of Tulare Lake in winter 1888–'89 shows that an extraordinary recession of the lake waters has occurred during the preceding year, being one of three of deficient rain-fall; the alkali salts having now accumulated so far that mussels and certain kinds of fish can not live in them any more, and other species show signs of distress. In respect to the future of the lake the question is raised whether it had better be drained so as to lay bare the extremely fertile lands now covered by its waters, reserving only a water-way that may be made navigable, or whether under certain conditions it might be utilized as a reservoir for irrigation waters. It is feared that the latter use is impracticable on account of the alkaline drainage that must come toward the lake from the higher-lying irrigated lands, when, as must soon be done, these shall be properly drained in order to prevent the "rise of the alkali" before referred to. In any case the necessity of the removal of the strongly saline water now contained in the lake basin is insisted on.

A fourth chapter discusses, from the stand-point of the chemist, the changes brought about in the composition of alkali salts by the action of carbonic acid, under different conditions of dilution. It is found that by such action, which constantly occurs in soils to a greater or less extent, the bland sulphates and chlorides can be transformed into corrosive carbonates, and that this action must be taken into account in considering the reclamation of alkali lands by the use of gypsum. Attention is called to the fact that this reaction, heretofore almost overlooked, is of the widest importance in the chemistry of geological formations.

Mr. MILLS. Mr. Marks desires to address the committee briefly.

Mr. MARKS. My specialty is colonization, and as your time is limited *I would rather* others should speak.

Mr. MILLS. I would like to have brought before the committee some testimony with regard to the colonization and settlement of the State. Your experience as a colonizing agent might be serviceable in that respect.

STATEMENT OF BERNHARD MARKS.

The CHAIRMAN. We would like to hear what you have to say upon the subject of irrigation, especially in this State.

Mr. MARKS. I do not intend to furnish the committee with any cumulative evidence on the advantages of irrigation. I had another point to present altogether, but inasmuch as Mr. Mills has called on me, I will say that my specialty is colonization. That is, I take into consideration those circumstances which will enable an intelligent family to live on irrigated land and use as small a piece of land as they can conveniently and properly cultivate. Perhaps the quickest way to get at my point would be to tell what has been done at Fresno.

Fifteen years ago, when the railroad was built through there, the town of Fresno was a mere hamlet. Any one could stand near that hamlet and sweep the horizon with a field-glass, and absolutely nothing would obstruct the view, not a shanty or even a tree. The whole expanse was a brown, bare, barren, repulsive desert waste of sand, and nothing else.

After having studied the soil and country, and after having made up my mind that it was a land specially adapted to the raisin and the vine, I laid off a piece of land 3 miles long and 2 miles wide, about 2½ miles from town; built 40 miles of ditch and 14 miles of canal; planted some miles of trees in order to make it fit for a family, and commenced the colonization of that country. That colony was a complete success. Now there are twenty-two colonies like that, surrounding the town of Fresno.

The great value of California to civilization, in my opinion, does not consist in its capacity to furnish a large profit to capital, or the raising of wine, raisins, oranges, or any one product. In my opinion the great value of California to civilization is that the combination of soil and climate is such that within its area an intelligent family accustomed to the amenities of civilization can acquire a better living and live in greater affluence with 10 acres of land than they can in any other country that I have ever read of.

At Fresno, if this committee goes there, they will see the result of irrigation. You may go through miles of avenues there, and every 660 feet you will meet with a handsome little cottage surrounded by its outbuildings, its orchard, its vineyard, its vegetable garden, its nursery, its alfalfa patch, its cow, staked out on the alfalfa, and its happy and prosperous inhabitants. You can go there and see all those things, every 660 feet—every eighth of a mile—and yet these people are taking their water almost literally at the muzzle of a gun. That is why I have come before you.

The United States Land Commissioner has issued to the various land officers instructions intended to prevent all acquisition of legal title to lands that may be selected for sites for reservoirs and canals, and lands susceptible to irrigation.

Inasmuch as these instructions show that this committee is taking cognizance of the legal feature of the irrigation matter, I beg most respectfully and most earnestly to express the opinion that the laudable efforts of the Land Commissioner to forestall legal complication will be

most likely to fail of accomplishment unless some way be found whereby other irrigable States and Territories may be protected from the legal calamities which now severely afflict California.

If I am making a mistake in assuming from the action of the Land Commissioner that this committee regards the legal aspect of irrigation as coming within the scope of its mission, it may eventually transpire that the important results of its labors will be nullified by unnecessary legal impediments. If, however, I am correct in the foregoing assumption, then will this committee ascertain that the settlement for the Territories by Congressional or other action of the legal difficulties which beset irrigation in this State is by far the most important, as it may be the most difficult, part of its work.

Assuming that a study of and a report by this honorable committee on this feature of the irrigation matter will result directly in such Federal and indirectly in such State legislation as will forever settle the title to the water of the natural water-courses in other States and Territories, I bespeak your earnest attention to the lamentable condition of water titles in California.

The physical, historical, legislative, and industrial conditions which dominated the State of California were such as should have abundantly secured it, if such security were possible, from such State supreme court decisions as have been rendered in this State; decisions which have paralyzed the State in all those enterprises which demand the use of running water, which have kept back in Fresno County alone an advance in population and property to the extent of 10,000 inhabitants and ten millions of capital in the last ten years; and which, if they had been rendered in the early days of California, would have either made mining impossible or would have compelled the miners to do what the farmers of California are doing to-day, viz, to use water in contravention of law and in defiance of the decrees of the courts.

The supreme court of California has always compared and does now compare, favorably in probity, ability, and legal learning with the similar tribunals of ultimate resort in other and older States; and yet, in spite of the favorable conditions I have alluded to, this honest and able supreme court has struck the State a blow more staggering in its effects than could have been dealt it by alien foe or hostile power.

That this committee may see the urgent necessity of endeavoring to protect other States and Territories from the calamitous decisions which now so severely injure California I will briefly set forth, with your permission, those favorable conditions which have failed to protect this State and which other States and Territories may not have the advantage of to so eminent a degree.

The San Joaquin Valley, the great valley of California, capable of sustaining in affluence a population of five millions, is a perfect model of a country specially suited to irrigation. In fact, it is not otherwise habitable to an agricultural people. The land has a general slope, which at the same time fits it for the economic application of water and affords ample opportunity for drainage. The nature of the soil is admirably adapted to surface irrigation. The rain-fall is insufficient for the production of the more valuable vegetation, but the rivers afford abundant water to supplement its scarcity. The water which in other countries is distributed over the entire surface of the land during the summer months is here accumulated in the form of snow upon the Sierras during the winter. The nature of the river-beds of this plain are admirably fitted *to perform* the peculiar service required of them. Instead of the rocky *bottoms of* eastern rivers, which favor the quick escape of superabun-

dant waters from land to sea, the rivers that water this plain have beds of absorbing sand which detain the well-gauged waters of the region and prevent their too rapid flow to the ocean. There are no bottom lands worth mentioning along these rivers, but the whole vast plain sustains to them the relation which entitles it to their fructifying influence. The climate of the region is not dependent upon latitude but upon altitude. Starting from any given point in the elliptical basin which constitutes the valley an isothermal line will describe a very eccentric ellipse and will return to the starting point. In brief, there is no other part of our country in which the physical conditions point so directly to the necessity of the kind of legislation and judicial decisions which obtain in irrigated countries.

Historically in favor of judicial decisions friendly to irrigation, California had the great advantage of the provisions of the treaty of Guadaloupe Hidalgo, which insured to the granted part of her territory the sensible and equitable Mexican laws concerning the distribution of water as against the wholly absurd and impracticable English common law of riparian rights.

In legislation the State was extremely fortunate. The legislation of the State affecting the use and distribution of its waters reflects credit on the intelligence of the pioneers of California. As in the case of other newly-constructed States, the legislature enacted that the English common law should be, not the law of the land, but the rule of decision in its courts; and, foreseeing just such contingencies as the disastrous application of the riparian part of the common law to the physical conditions of the State, it enacted that the English common law should not be applied in cases in which it should be repugnant to or inconsistent with the laws of Congress or of the State.

At successive sessions of the legislature laws were enacted to regulate the acquisition of the right to use water for beneficial purposes.

The foundation of these laws was the right of prior appropriation as opposed to the English law of riparian rights. Under these laws it was utterly impossible for any natural or artificial person to acquire title to a single drop of water. Title could be acquired only to the use of water, and only to the quantity of water actually used. No person or corporation could acquire the right to run a drop of water to willful or heedless waste, or to prevent any other person from using water not actually in beneficial use by a prior appropriator. No vested right could accrue to any person or corporation by which water not in use could be kept from others desirous of using it. The water law of California is the perfection of equity and wisdom, and yet it was wholly set aside by the State supreme court and the English common law of riparian rights substituted in its stead.

The industrial conditions which California was in position to rely upon for protection against decisions adverse to her irrigation interests were comprised in the fact that during the whole time of the operation of her water law, which included almost the whole life of the State, all the mining, milling, and irrigation enterprises were established; untold and almost untellable millions of capital were invested and property developed; and upon the stability of these properties depended almost the entire taxable value of the State.

It is difficult to see how a State or Territory could be better equipped to resist the destructive application of the English common law of riparian rights to a physical condition wholly at variance with its principles. Nevertheless the decisions of the supreme court of California have fastened upon the State the following destructive principles:

The English common law prevails in California not only as it stood at the time when the United States separated from England, but as it has since been changed from time to time in England to suit the exigencies of English affairs.

All the water in the State that falls from the clouds or results from the melting snow is the absolute private property of the few persons who own the strips of land bordering on the natural river-courses of the State.

The rigid riparian rule that the water must flow past its riparian owners undiminished in quantity and unimpaired in quality may be modified so far as to recognize the right of the riparian owners themselves to divert water upon their own riparian lands subject only to each others' rights.

The California supreme court rejects the modification of the rule by which English judges, in accordance with the same English common law, suspend its disastrous operation in cases to which it is not properly applicable, as in Australia and India.

There is no way to acquire the right to use any of the water of the State for any purpose except to purchase it by private agreement or through the operation of the law of eminent domain.

Inasmuch as the law of eminent domain may be invoked only for a public use, it follows that no person or corporation, nor any number of persons or corporations, can acquire the right to water for their own use, no matter how necessary or beneficial that use may be. They must invest sufficient capital to buy water for the general public in addition to what they may need for their own use, even though they may never be able to sell what they buy for that purpose.

The foregoing propositions having been settled by the decisions of the majority of the supreme court, the legislature of California enacted a law known as the Wright bill, which is intended to enable those who may desire to operate under its provisions to construct canals and purchase water by taxing lands susceptible to irrigation for the purpose of selling said water to the general public.

The reasons why the Wright bill is impracticable and unnecessary are too many to be here presented; but it will suffice to say that the people of California, outside of the cities, want water in but small measure for a public, but in a great measure for a private use; that, as no legislation can be of an *ex post facto* character, the damage inflicted by riparian decisions can never be repaired by legislation; and that so long as a majority of the State supreme court entertains English riparian opinions the prosperity of the State dependent upon the use of flowing water can not advance and must recede.

If the States and Territories in which the operations of this committee are intended to stimulate the adoption and establishment of systems of irrigation are destined to be covered by supreme court riparian decisions founded on the recognition of the English common law of riparian rights, then will the irrigation that will be practiced be very small in comparison with the litigation that will be developed.

The experience of California makes manifest the following propositions:

A system of irrigation founded on the principle of prior appropriation is the only one that is practicable under a non-paternal government. Under such a system there is no such thing as property in water. Those who wish to use water for mining, milling, or irrigation may acquire the *right to* use it and will be prevented from monopolizing any water not *actually* in use.

The element of speculation in the water of the State is wholly eliminated. Its public use may be as effectively subserved by the appropriation under the law of free public water as by condemnation and purchase of private rights.

Appropriation and condemnation are inconsistent with and antagonistic to each other.

There is neither equity nor sound public policy in allowing private individuals to acquire title to water-courses which they did not create and to the results of the forces of nature which they do not control.

In the early days of California most of the land was the property of the Federal Government. The running waters were deemed public property and were considered as dedicated to the use of the people.

Congress expressly sanctioned the appropriation of water on the public domain and authorized it by enactment in 1866. That enactment seemed to be insufficient to deter the California supreme court from applying the English common law of riparian rights to the destruction of irrigation, mining, and milling in California. If, through the action of this committee, Congress shall be led to enact such further laws as will effectually protect the Government land in the Territories from the application to them of the English common law, then will this committee have done infinitely more for irrigation than it could possibly do in making preliminary surveys for reservoirs and canals.

Mr. ESTEE. If the committee please, so far as this report is concerned, it is an able one, but I wish the committee to understand that the State board of trade has no quarrel with the supreme court, whatever the opinion of that court may be. We are not here to present any fight against the supreme court of our State.

So far as concerns the effect of the decision referred to by Mr. Marks on the free use of water, the article may be generally right or wrong as the case may be, but this board does not assume the position of criticising the court. We are here to present facts and not arguments against our supreme court. I do not suppose any power can control the waters of this State, except the navigable waters.

Mr. MARKS. I do not represent the State board of trade, but the people of Fresno whose homes are in danger. It is for this committee to say whether they will consider it worth while to report to Congress in reference to enacting such laws as will be a guide not only to the supreme court of California but to those of other Territories to be erected into States.

SAN FRANCISCO, *August* 26.

STATEMENT OF N. P. CHIPMAN, OF RED BLUFF.

The CHAIRMAN. We should be glad to hear any views you may desire [illegible] to the committee on the subject of irrigation.

[illegible]MAN. I have just one word that I desire to say tending to [illegible]rrigation in California. I live in the north[illegible] portion of the State so far as nature [illegible]standing that we have a climate [illegible] highly prized in the southern part [illegible] withstanding that we have a rich [illegible]r wheat county of the world—not

withstanding all that, a year and a half ago when I was called on to make an agricultural address and wanted to get at some practical point and to develop some possible remedy for the lack of emigration into northern California, I found two things existing: First, that a gradual increase of the assessment roll, the gradual and rapid enchancement of values in this State, was taking place in the southern portion of California. The filling up of the State, the increased population, was occurring in the southern part; and I found that but for irrigation the lands down there, which were filling up and were enhancing so rapidly in value, were really valueless, while ours, with the water which nature has bestowed upon us—with an equally splendid climate and everything to make homes attractive, were not getting a share of the population. I came to the conclusion that it was a simple question of irrigation, even in northern California. So have the people of northern California come to that conclusion. Therefore in Colusa County they are now burdening themselves with a million and a half dollars of debt in order to bring water into the banner county of the world.

Mr. ESTEE. Mr. Wright is present; he has been the author of all our leading legislation on irrigation. Perhaps you would like to hear him for a few minutes; I know he can interest you.

The CHAIRMAN. We shall be glad to hear Mr. Wright.

STATEMENT OF C. C. WRIGHT.

The CHAIRMAN. Anything that you desire to say on the general subject that we are investigating we shall be glad to hear. Anything of special interest to irrigation in California will instruct the committee.

Mr. WRIGHT. I do not desire to detain the committee with any extended remarks, but perhaps I could do no better than to simply call the attention of the committee to the irrigation law of 1887—the law which it seems has been so severely criticised here. The criticism I shall not advert to further than to say that the judgment of the gentleman is at variance with that of about nine-tenths of the people in the irrigable portion of California.

That act has for its object the irrigation of all the territory in California which may be easily accessible to a common source of supply, and so that all the people may by common effort irrigate the land. Under that act about twenty districts have been organized in this State. The people who have organized those districts look to this Senatorial committee with some hope that they may get some material aid from the Government for the purpose of irrigating their land.

It is a well-known fact that there would not be sufficient water to water all this land in California that required irrigation without a storage system. That is indispensable. A storage system must be created, and inasmuch as this committee has that particular subject in hand, has for its object, as I understand, the selection of reservoir sites——

The CHAIRMAN. The committee has simply in hand the investigation of facts. It is not to commit Congress to any special course.

Mr. WRIGHT. That is what I understand. The facts being obtained, if the Government should engage in the work of constructing reservoirs or creating a water supply it would be an incalculable advantage to the people of this State. I do not know to what extent the Government would agree to go in this matter, but these districts, if they lack anything at all, simply lack a supply of water with which to water their lands. If the Government will give attention and aid in that particular, it will give aid that no other power can do so well.

The CHAIRMAN. Would surveys be of service and the ascertainment of the facts as to the amount of money necessary to complete a thorough system of irrigation; would those aid the people?

Mr. WRIGHT. Very materially. The engineer who was present here to-day, and who knows more, perhaps, than any other man in this State, remarked to me to-day that it would be a very material aid. So with the reservoir sites.

Senator JONES. What powers are conveyed by the law of 1887, to which you referred, on these districts?

Mr. WRIGHT. The first power is that of organization; then the power to provide for the creation of indebtedness sufficient to construct the works; then the power to condemn wherever that may be necessary—in other words, the exercise of the right of eminent domain; and the acquisition of the necessary rights for the condemnation of existing works, whenever that may be found advisable; also the power to hold elections, and to assess and collect a revenue for the purpose of defraying expenses, and the general powers of a municipal corporation.

Mr. ESTEE. Also that they are to distribute the waters equitably and by general rules.

Mr. WRIGHT. Yes.

Senator JONES. By what names are those organizations known—as irrigation districts?

Mr. WRIGHT. Yes. The law provides that five directors shall be elected for each district, who shall have the power to control the distribution of the water and all matters connected with the conduct of the district.

Senator JONES. Do they have the power to collect money and expend it?

Mr. WRIGHT. Yes. They exercise some duties kindred to those of the supervisors of the county.

Mr. ESTEE. There is a gentlemen here from Los Angeles who will not detain the committee more than a moment.

Senator JONES. Before he begins I would like to ask Mr. Wright one question more. In the practical working of this law, has there been any difficulty in defining the limits of those irrigation districts?

Mr. WRIGHT. None whatever.

Senator JONES. Has that been regulated by the water commissioners?

Mr. WRIGHT. Yes; they include in one district all the land that can be easily watered from one source.

Senator JONES. The intention, then, is to embrace in the system only such lands as can be irrigated?

Mr. WRIGHT. Yes.

Senator JONES. Suppose a valley has to be surrounded by a lot of hills—the hill-sides that are above the line of irrigation are not included in those irrigation districts, are they?

Mr. WRIGHT. No; only such lands as may be actually reached by the water.

Mr. MILLS. And the bonds that are issued are a mortgage on those lands?

The CHAIRMAN. You only include in your district land that may be irrigated, but, to obtain water, you may have to go outside of the land to be irrigated?

Mr. WRIGHT. Yes; that is the idea. I desire to make one further suggestion, and that is, that we have pamphlet copies of this irrigation law, and will supply the committee with a copy. (See Exhibit D.)

EXHIBIT D.

WRIGHT IRRIGATION BILL AND AMENDMENTS, 1889.

CHAPTER XXXIV. An Act to provide for the organization and government of irrigation districts and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. Whenever fifty or a majority of freeholders owning lands susceptible of one mode of irrigation from a common source, and by the same system of works, desire to provide for the irrigation of the same, they may propose the organization of an irrigation district under the provisions of this act, and when so organized such district shall have the powers conferred or that may hereafter be conferred by law upon such irrigation district.

SEC. 2. A petition shall first be presented to the board of supervisors of the county in which the lands or the greatest portion thereof is situated, signed by the required number of freeholders of such proposed district, which petition shall set forth and particularly describe the proposed boundaries of such district, and shall pray that the same may be organized under the provisions of this act. The petitioners must accompany the petition with a good and sufficient bond, to be approved by the said board of supervisors, in double the amount of the probable cost of organizing such district, conditioned that the bondsmen will pay all said cost in case said organization shall not be effected. Such petition shall be presented at a regular meeting of the said board, and shall be published for at least two weeks before the time at which the same is to be presented, in some newspaper printed and published in the county where said petition is presented, together with a notice stating the time of the meeting at which the same will be presented. When such petition is presented, the said board of supervisors shall hear the same, and may adjourn such hearing from time to time, not exceeding four weeks in all; and on the final hearing may make such changes in the proposed boundaries as they may find to be proper, and shall establish and define such boundaries: *Provided*, That said board shall not modify said boundaries so as to except from the operation of this act any territory within the boundaries of the district proposed by said petitioners, which is susceptible of irrigation by the same system of works applicable to the other lands in such proposed district, nor shall any lands which will not, in the judgment of the said board, be benefited by irrigation by said system be included within such district: *Provided*, That any person whose lands are susceptible of irrigation from the same source shall, upon application of the owner to said board, be entitled to have such lands included in said district. Said board shall also make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered First, Second, Third, Fourth, and Fifth, and one director shall be elected from each district. Said board of supervisors shall then give notice of an election to be held in such proposed district, for the purpose of determining whether or not the same shall be organized under the provisions of this act. Such notice shall describe boundaries so established, and shall designate a name for such proposed district, and said notice shall be published for at least three weeks prior to such election in a newspaper published within said county; and if any portion of such proposed district lie within another county or counties, then said notice shall be published in a newspaper published within each of said counties. Such notice shall require the electors to cast ballots which shall contain the words, "Irrigation district—Yes;" or, "Irrigation district—No," or words equivalent thereto; and also the names of persons to be voted for to fill the various elective offices hereinafter prescribed. No person shall be entitled to vote at any election held under the provisions of this act unless he shall possess all the qualifications required of electors under the general election laws of this State.

SEC. 3. Such election shall be conducted in accordance with the general election laws of the State, provided that no particular form of ballot shall be required. The said board of supervisors shall meet on the second Monday next succeeding such election, and proceed to canvass the votes thereat; and if upon such canvass it appear that at least two-thirds of all the votes cast are "Irrigation district—Yes," the said Board shall, by an order entered on their minutes, declare such territory duly organized as an irrigation district, under the name and style theretofore designated, and shall declare the persons receiving, respectively, the highest number of votes for such several offices to be duly elected to such offices. Said board shall cause a copy of such order, duly certified, to be immediately filed for record in the office of the county *recorder* of each county in which any portion of such lands are situated, and must also *immediately forward* a copy thereof to the clerk of the board of supervisors of each

of the counties in which any portion of the district may lie; and no board of supervisors of any county, including any portion of such district, shall, after the date of the organization of such district, allow another district to be formed including any of the lands in such district, without the consent of the board of directors thereof; and from and after the date of such filing, the organization of such district shall be complete, and the officers thereof shall be entitled to enter immediately upon the duties of their respective offices, upon qualifying in accordance with law, and shall hold such offices respectively, until their successors are elected and qualified. For the purposes of the election above provided for, the said board of supervisors must establish a convenient number of election precincts in said proposed district, and define the boundaries thereof, which said precincts may thereafter be changed by the board of directors of such district.

SEC. 4. An election shall be held in such district on the first Wednesday in April, eighteen hundred and eighty-eight, and on the first Wednesday in April in each second year thereafter, at which an assessor, a collector, and a treasurer, and a board of five directors for the district shall be elected. The person receiving the highest number of votes for any office to be filled at such election is elected thereto. Within ten days after receiving their certificates of election, hereinafter provided for, said officers shall take and subscribe the official oath and file the same in the office of the board of directors. The assessor shall execute an official bond in the sum of ten thousand dollars, and the collector an official bond in the sum of twenty thousand dollars, and the district treasurer an official bond in the sum of fifty thousand dollars; each of said bonds to be approved by the board of directors; and each member of said board of directors shall execute an official bond in the sum of twenty-five thousand dollars, which said bonds shall be approved by the judge of the superior court of said county where such organization was effected and shall be recorded in the office of the county recorder thereof, and filed with the secretary of said board. All official bonds herein provided for shall be in form prescribed by law for the official bonds of county officers.

SEC. 5. Fifteen days before any election held under this act, subsequent to the organization of any district, the secretary of the board of directors shall cause notice to be posted in three public places in each election precinct, of the time and place of holding the election, and shall also post a general notice of the same in the office of said board, which shall be established and kept at some fixed place to be determined by said board, specifying the polling places of each precinct. Prior to the time for posting the notices, the board must appoint for each precinct, from the electors thereof, one inspector and two judges, who shall constitute a board of election for such precinct. If the board fail to appoint a board of election, or the members appointed do not attend at the opening of the polls on the morning of election, the electors of the precinct present at that hour may appoint the board, or supply the place of an absent member thereof. The board of directors must, in its order appointing the board of election, designate the house or place within the precinct where the election must be held.

SEC. 6. The inspector is chairman of the election board, and may:

First. Administer all oaths required in the progress of an election.

Second. Appoint judges and clerks, if during the progress of the election any judge or clerk cease to act. Any member of the board of election, or any clerk thereof, may administer and certify oaths required to be administered during the progress of an election. The board of election for each precinct must, before opening the polls, appoint two persons to act as clerks of the election. Before opening the polls, each member of the board and each clerk must take and subscribe an oath to faithfully perform the duties imposed upon them by law. Any elector of the precinct may administer and certify such oath. The polls must be opened one hour after sunrise on the morning of the election, and be kept open until sunset, when the same must be closed. The provisions of the Political Code concerning the form of ballots to be used shall not apply to elections held under this act.

SEC. 7. Voting may commence as soon as the polls are opened, and may be continued during all the time the polls remain opened, and shall be conducted as nearly as practicable in accordance with the provisions of chapter nine of title two of part three of the Political Code of this State. As soon as the polls are closed, the judges shall open the ballot-box and commence counting the votes; and in no case shall the ballot-box be removed from the room in which the election is held until all the ballots have been counted. The counting of ballots shall in all cases be public. The ballots shall be taken out, one by one, by the inspector or one of the judges, who shall open them and read aloud the names of each person contained therein, and the office for which every such person is voted for. Each clerk shall write down each office to be filled, and the name of each person voted for for such office, and shall keep the number of votes by tallies as they are read aloud by the inspector or judge. The counting of votes shall be continued without adjournment until all have been counted.

SEC. 8. As soon as all the votes are read off and counted, a certificate shall be drawn

up on each of the papers containing the poll list and tallies, or attached thereto, stating the number of votes each one voted for has received, and designating the office to fill which he was voted for, which number shall be written in figures and in words at full length. Each certificate shall be signed by the clerk, judge, and the inspector. One of said certificates, with the poll list and the tally paper to which it is attached, shall be retained by the inspector, and preserved by him at least six months. The ballots shall be strung upon a cord or thread by the inspector, during the counting thereof, in the order in which they are entered upon the tally list by the clerks; and said ballots, together with the other of said certificates, with the poll list and tally paper to which it is attached, shall be sealed by the inspector in the presence of the judges and clerks, and indorsed "Election returns of (naming the precinct) precinct," and be directed to the secretary of the board of directors, and shall be immediately delivered by the inspector, or by some other safe and responsible carrier designated by said inspector, to said secertary, and the ballots shall be kept unopened for at least six months, and if any person be of the opinion that the vote of any precinct has not been correctly counted, he may appear on the day appointed for the board of directors to open and canvass the returns, and demand a recount of the vote of the precinct that is so claimed to have been incorrectly counted.

SEC. 9. No list, tally paper, or certificate returned from any election shall be set aside or rejected for want of form if it can be satisfactorily understood. The board of directors must meet at its usual place of meeting on the first Monday after each election to canvass the returns. If at the time of meeting the returns from each precinct in the district in which the polls were opened have been received, the board of directors must then and there proceed to canvass the returns; but if all the returns have not been received the canvass must be postponed from day to day until all the returns have been received, or until six postponements have been had. The canvass must be made in public and by opening the returns and estimating the vote of the district for each person voted for and declaring the result thereof.

SEC. 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show:

First. The whole number of votes cast in the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in the district to each of such persons.

The board of directors must declare elected the person having the highest number of votes given for each office to be filled by the votes of the district. The secretary must immediately make out and deliver to such person a certificate of election signed by him and authenticated with the seal of the board. In case of a vacancy in the office of assessor, tax collector, or treasurer, the vacancy shall be filled by appointment by the board of directors. In case of a vacancy in the office of member of the board of directors, the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board is situated. An officer appointed as above provided shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 11. On the first Wednesday in May next following their election the board of directors shall meet and organize as a board, elect a president from their number, and appoint a secretary. The board shall have the power, and it shall be their duty, to manage and conduct the business and affairs of the district, make and execute all necessary contracts, employ and appoint such agents, officers, and employés as may be required, and prescribe their duties, establish equitable by-laws, rules, and regulations for the distribution and use of water among the owners of said lands, and generally to perform all such acts as shall be necessary to fully carry out the purposes of this act. The said by-laws, rules, and regulations must be printed in convenient form for distribution in the district. And it is hereby expressly provided that all waters distributed for irrigation purposes shall be apportioned rateably to each land owner upon the basis of the ratio which the last assessment of such owner for district purposes within said district bears to the whole sum assessed upon the district: *Provided*, That any land owner may assign the right to the whole or any portion of the waters so apportioned to him.

SEC. 12. The board of directors shall hold a regular monthly meeting in their office on the first Tuesday in every month, and such special meetings as may be required for the proper transaction of business: *Provided*, That all special meetings must be ordered by a majority of the board; the order must be entered of record, and five days' notice thereof must, by the secretary, be given to each member not joining in the order. The order must specify the business to be transacted, and none other than that specified must be transacted at such special meeting. All meetings of the board *must be public*, and three members shall constitute a quorum for the transaction of *business, but on all questions* requiring a vote there shall be a concurrence of at

least three members of said board. All records of the board shall be open to the inspection of any elector during business hours. The board and its agents and employés shall have the right to enter upon any land in the district to make surveys, and may locate the line for any canal or canals, and the necessary branches for the same, on any of said lands which may be deemed best for such location. Said board shall also have the right to acquire, either by purchase or condemnation, all lands and waters and other property necessary for the construction, use, supply, maintenance repair, and improvement of said canal or canals and works, including canals and works constructed and being constructed by private owners, lands for reservoirs, for the storage of needful waters, and all necessary appurtenances. In case of purchase the bonds of the district, hereinafter provided for, may be used at their par value in payment; and in case of condemnation the board shall proceed in the name of the district under the provisions of title seven of part three of the code of civil procedure. Said board may also construct the necessary dams, reservoirs, and works for the collection of water for said district, and do any and every lawful act necessary to be done, that sufficient water may be furnished to each land owner in said district for irrigation purposes. The use of all water required for the irrigation of the lands of any district formed under the provisions of this act, together with rights of way for canals and ditches, sites for reservoirs, and all other property required in fully carrying out the provisions of this act, is hereby declared to be a public use, subject to the regulation and control of the State in the manner prescribed by law.

SEC. 13. The legal title to all property acquired under the provisions of this act shall immediately and by operation of law vest in such irrigation district, and shall be held by such district in trust for and is hereby dedicated and set apart to the uses and purposes set forth in this act. And said board is hereby authorized and empowered to hold, use, acquire, manage, occupy, and possess said property as herein provided.

SEC. 14. The said board is hereby authorized and empowered to take conveyances or other assurances for all property acquired by it under the provisions of this act, in the name of such irrigation district, to and for the uses and purposes herein expressed, and to institute and maintain any and all actions and proceedings, suits at law or in equity, necessary or proper in order to fully carry out the provisions of this act, or to enforce, maintain, protect, or preserve any and all rights, privileges, and immunities created by this act or acquired in pursuance thereof. And in all courts, actions, suits, or proceedings the said board may sue, appear, and defend, in person or by attorneys, and in the name of such irrigation district.

SEC. 15. For the purpose of constructing necessary irrigating canals and works and acquiring the necessary property and rights therefor, and otherwise carrying out the provisions of this act, the board of directors of any such district must, as soon after such district has been organized as may be practicable, estimate and determine the amount of money necessary to be raised, and shall immediately thereupon call a special election, at which shall be submitted to the electors of such district possessing the qualifications prescribed by this act the question whether or not the bonds of said district shall be issued in the amount so determined. Notice of such election must be given by posting notices in three public places in each election precinct in said district for at least twenty days, and also by publication of such notice in some newspaper published in the county where the office of the board of directors of such district is required to be kept once a week for at least three successive weeks. Such notices must specify the time of holding the election, the amount of bonds proposed to be issued, and said election must be held and the result thereof determined and declared in all respects as nearly as practicable in conformity with the provisions of this act governing the election of officers: *Provided*, That no informalities in conducting such an election shall invalidate the same if the election shall have been otherwise fairly conducted. At such election the ballots shall contain the words, "Bonds—Yes," or "Bonds—No," or words equivalent thereto. If a majority of the votes cast are "Bonds—Yes," the board of directors shall immediately cause bonds in said amount to be issued; said bonds shall be payable in gold coin of the United States in installments as follows, to wit: At the expiration of eleven years not less than five per cent. of said bonds; at the expiration of twelve years not less than six per cent.; at the expiration of thirteen years not less than seven per cent.; at the expiration of fourteen years not less than eight per cent.; at the expiration of fifteen years not less than nine per cent.; at the expiration of sixteen years not less than ten per cent.; at the expiration of seventeen years not less than eleven per cent.; at the expiration of eighteen years not less than thirteen per cent.; at the expiration of nineteen years not less than fifteen per cent.; and for the twentieth year a percentage sufficient to pay off said bonds; and shall bear interest at the rate of six per cent. per annum, payable semiannually on the first day of January and July of each year. The principal and interest shall be payable at the office of the treasurer of the district. Said bonds shall be each of the denomination of not less than one hundred dollars, nor more than five hundred dollars, shall be negotiable in form, signed by the president and secre-

tary, and the seal of the board of directors shall be affixed thereto. T
numbered consecutively as issued, and bear date at the time of their issue.
for the interest shall be attached to each bond signed by the secretary.
shall express on their face that they were issued by authority of this ac
title and date of approval. The secretary shall keep a record of the bon
number, the date of sale, the price received, and the name of the purcha

SEC. 16. The board may sell said bonds from time to time in such quan
be necessary and most advantageous to raise money for the constru
canals and works, the acquisition of said property and rights, and othe
carry out the objects and purposes of this act. Before making any sa
shall, at a meeting, by resolution, declare its intention to sell a specifi
the bonds and the day and hour and place of such sale, and shall cause
to be entered in the minutes, and notice of the sale to be given by publi
at least twenty days in a daily newspaper published in each of the cit
cisco, Sacramento, and Los Angeles, and in any other newspaper, at t
The notice shall state that sealed proposals will be received by the
office for the purchase of the bonds till the day and hour named in the
the time appointed the board shall open the proposals and award the
bonds to the highest responsible bidder, and may reject all bids; but sa
in no event sell any of the said bonds for less than ninety per cent. of
thereof.

SEC. 17. Said bonds, and the interest thereon, shall be paid by
from an annual assessment upon the real property of the district; a
property in the district shall be and remain liable to be assessed for s
hereinafter provided.

SEC. 18. The assessor must, between the first Monday in March an
day in June in each year, assess all real property in the district, to
own, claim, have the possession or control thereof, at its full cash
prepare an assessment book with appropriate headings, in which
such property within the district, in which must be specified in
under the appropriate head:

First. The name of the person to whom the property is assessed.
known to the assessor, the property shall be assessed to "unknown

Second. Land by township, range, section, or fractional section
land is not a Congressional division or subdivision, by metes and bo
scription sufficient to identify it, giving an estimate of the numbe
and the improvements thereon.

Third. City and town lots, naming the city or town, and the
according to the system of numbering in such city or town, and
thereon.

Fourth. The cash value of real estate, other than city or town

Fifth. The cash value of improvements on such real estate.

Sixth. The cash value of city and town lots.

Seventh. The cash value of improvements on city and town

Eighth. The cash value of improvements on real estate asse
than the owners of the real estate.

Ninth. The total value of all property assessed.

Tenth. The total value of all property after equalization by
ors.

Eleventh. Such other things as the board of directors may r

SEC. 19. The board of directors must allow the assessor as
appointed by him, as will, in the judgment of the board, enabl
assessment within the time herein prescribed. The board mus
of such deputies, which shal
pensation must
engaged, nor
day in Marc
SEC. 20.
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and the board may change the valuation as may be just. The secretary of the board shall be present during its sessions, and note all changes made in the valuation of property, and in the names of the persons whose property is assessed; and within ten days after the close of the session he shall have the total values, as finally equalized by the board, extended into columns and added.

SEC. 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds; and at the expiration of ten years after the issuing of bonds by the board, must increase said assessment for the ensuing ten years, in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year, six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year, eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten per cent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assesment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of [naming the district] irrigation district."

SEC. 23. The assessment upon real property is a lien against the property assessed from and after the first Monday in March for any year; and such lien is not removed until the assessments are paid or the property sold for the payment thereof.

SEC. 24. On or before the first day of November the secretary must deliver the assessment book to the collector of the district, who shall, within twenty days, publish a notice in a newspaper published in each of the counties comprising the district, if there be lands situated in more than one county in such district, that said assessments are due and payable and will become delinquent at 6 o'clock p. m. on the last Monday of December next thereafter; and that unless paid prior thereto five per cent. will be added to the amount thereof, and also the time and place at which payment of assessments may be made. The notice shall also specify a time and place within each election precinct of the district when and where the collector will attend to receive payment of assessments, and shall be published for fifteen days, and a printed copy of said notice shall be posted for the same time in some public place in each precinct. The collector must attend at the time and place specified in the notice to receive assessments, which must be paid in gold and silver coin. He must mark the date of payment of any assessment in the assessment book opposite the name of the person paying, and give a receipt to such person, specifying the amount of the assessment and the amount paid, with a description of the property assessed. On the thirty-first day of December of each year all unpaid assessments are delinquent, and thereafter the collector must collect thereon, for the use of the district, an addition of five per cent.

SEC. 25. On or before the first day of February, the collector must publish the delinquent list, which must contain the names of the persons and a description of the property delinquent, and the amount of the assessments and costs due opposite each name and description. He must append to and publish with the delinquent list a notice, that unless the assessments delinquent, together with cost and percentage, are paid, the real property upon which such assessments are a lien will be sold at public auction. The publication must be made once a week for three successive weeks in a newspaper published in each of the counties comprised in the district. The publication must designate the time and place of sale. The time of sale must not be less than twenty-one nor more than twenty-eight days from the first publication, and the place must be at some point designated by the collector.

SEC. 26. The collector must collect, in addition to the assessments due on the delinquent list and five per cent. added, fifty cents on each lot, piece, or tract of land separately assessed, one-half of which must go to the district and the other to the collector for preparing the list. On the day fixed for the sale, or some subsequent day to which he may have postponed it, of which he must give notice, the collector, between the hours of ten o'clock a. m. and three o'clock p. m., must commence the sale of the property advertised, commencing at the head of the list and continuing alphabetically, or in the numerical order of the lots or blocks, until completed. He may postpone the day of commencing the sales, or the sale, from day to day, but the sale must be completed within three weeks from the day first fixed.

SEC. 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed, then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the

purchaser does not pay the assessments and costs before ten o'clock a. m. the following day, the property, on next sale day, before the regular sale, must be resold for the assessments and costs. After receiving the amount of assessments and costs, the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the name of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and the year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser, and the other filed in the office of the county recorder of the county in which the land sold is situated.

SEC. 28. The collector, before delivering any certificate, must in a book enter a description of the land sold, corresponding with the description in the certificate, the date of the sale, purchasers' names, and amount paid, regularly number the description on the margin of the book and put a corresponding number on each certificate. Such book must be open to public inspection, without fee, during office hours, when not in actual use. On filing the certificates with such county recorder the lien of the assessments vests with the purchaser, and is only divested by the payment to him, or to the collector for his use, of the purchase money and two per cent. per month from the day of sale until redemption.

SEC. 29. A redemption of the property sold may be made by the owner, or any party in interest, within twelve months from the date of purchase. Redemption must be made in gold or silver coin, as provided for the collection of State and county taxes, and when made to the collector he must credit the amount paid to the person named in the certificate, and pay it, on demand, to the person or his assignees. In each report the collector makes to the board of directors he must name the person entitled to redemption money, and the amount due to each. On receiving the certificate of sale, the county recorder must file it and make an entry in a book similar to that required of the collector. On the presentation of the receipt of the person named in the certificate, or of the collector for his use, of the total amount of redemption money, the recorder must mark the word "redeemed," the date, and by whom redeemed, on the certificate and on the margin of the book where the entry of the certificate is made. If the property is not redeemed within twelve months from the sale, the collector, or his successor in office, must make to the purchaser or his assignee a deed of the property, reciting in the deed substantially the matters contained in the certificate, and that no person redeemed the property during the time allowed by law for its redemption. The collector shall receive from the purchaser, for the use of the district, two dollars for making such deed.

SEC. 30. The matter recited in the certificate of sale must be recited in the deed, and such deed duly acknowledged or proved is prima facie evidence that—

First.—The property was assessed as required by law.

Second.—The property was equalized as required by law.

Third.—That the assessments were levied in accordance with law.

Fourth.—The assessments were not paid.

Fifth.—At a proper time and place the property was sold as prescribed by law and by the proper officer.

Sixth.—The property was not redeemed.

Seventh.—The person who executed the deed was the proper officer.

Such deed, duly acknowledged or proved, is (except as against actual fraud) conclusive evidence of the regularity of all the proceedings from the assessment by the assessor, inclusive, up to the execution of the deed. The deed conveys to the grantee the absolute title to the lands described therein, free of all incumbrances, except when the land is owned by the United States or this State, in which case it is prima facie evidence of the right of possession.

SEC. 31. The assessment book or delinquent list, or a copy thereof, certified by the collector, showing unpaid assessments against any person or property, is prima facie evidence of the assessment, the property assessed, the delinquency, the amount of assessments due and unpaid, and that all the forms of the law in relation to the assessment and levy of such assessments have been complied with.

SEC. 32. When land is sold for assessments correctly imposed, as the property of a particular person, no misnomer of the owner or supposed owner, or other mistake relating to the ownership thereof, affects the sale or renders it void or voidable.

SEC. 33. On the first Monday in each month the collector must settle with the secretary of the board for all moneys collected for assessments, and pay the same over to the treasurer; and within six days thereafter he must deliver to and file in the office of the secretary a statement under oath, showing:

First. An account of all his transactions and receipts since his last settlement.

Second. That all money collected by him as collector has been paid.

The collector shall also file in the office of the secretary on said first Monday in *each month* the receipt of the treasurer for the money so paid.

SEC. 34. Upon the presentation of the coupons due to the treasurer, he shall pay

the same from said bond fund. Whenever after ten years from the issuance of said bonds, said fund shall amount to the sum of ten thousand dollars, the board of directors may direct the treasurer to pay such an amount of said bonds not due as the money in said fund will redeem, at the lowest value at which they may be offered for liquidation, after advertising for at least four weeks in some daily newspaper in each of the cities hereinbefore named, and in any other newspaper which said board may deem advisable, for sealed proposals for the redemption of said bonds. Said proposals shall be opened by the board in open meeting, at a time to be named in the notice, and the lowest bid for said bonds must be accepted: *Provided*, That no bond shall be redeemed at a rate above par. In case the bids are equal, the lowest numbered bond shall have the preference. In case none of the holders of said bonds shall desire to have the same redeemed, as herein provided for, said money shall be invested by the treasurer, under the direction of the board, in United States gold-bearing bonds, or the bonds of the State, which shall be kept in said "bond fund," and may be used to redeem said district bonds whenever the holders thereof may desire.

SEC. 35. After adopting a plan of said canal or canals, storage, reservoirs, and works, the board of directors shall give notice, by publication thereof not less than twenty days in one newspaper published in each of the counties composing the district, provided a newspaper is published therein, and in such other newspapers as they may deem advisable, calling for bids for the construction of said work, or of any portion thereof; if less than the whole work is advertised, then the portion so advertised must be particularly described in such notice; said notice shall set forth that plans and specifications can be seen at the office of the board, and that the board will receive sealed proposals therefor, and that the contract will be let to the lowest responsible bidder, stating the time and place for opening said proposals, which at the time and place appointed shall be opened in public, and as soon as convenient thereafter the board shall let said work, either in portions or as a whole, to the lowest responsible bidder, or they may reject any or all bids and readvertise for proposals, or may proceed to construct the work under their own superintendence with the labor of the residents of the district. Contracts for the purchase of material shall be awarded to the lowest responsible bidder. Any person or persons to whom a contract may be awarded shall enter into a bond, with good and sufficient sureties, to be approved by the board, payable to said district for its use, for double the amount of the contract price, conditional for the faithful performance of said contract. The work shall be done under the direction and to the satisfaction of the engineer, and be approved by the board.

SEC. 36. No claim shall be paid by the treasurer until allowed by the board, and only upon a warrant signed by the president, and countersigned by the secretary: *Provided*, That the board may draw from time to time from the construction fund and deposit in the county treasury of the county where the office of the board is situated, any sum in excess of the sum of twenty-five thousand dollars. The county treasurer of said county is hereby authorized and required to receive and receipt for the same, and place the same to the credit of said district, and he shall be responsible upon his official bond for the safe-keeping and disbursement of the same, as in this act provided. He shall pay out the same, or any portion thereof, to the treasurer of the district only, and only upon the order of the board, signed by the president and attested by the secretary. The said county treasurer shall report in writing on the second Monday in each month the amount of money in the county treasury, the amount of receipts for the month preceding, and the amount or amounts paid out; said report shall be verified and filed with the secretary of the board. The district treasurer shall also report to the board, in writing, on the first Monday in each month, the amount of money in the district treasury, the amount of receipts for the month preceding, and the amount and items of expenditures, and said report shall be verified and filed with the secretary of the board.

SEC. 37. The cost and expense of purchasing and acquiring property and constructing the works and improvements herein provided for, shall be wholly paid out of the construction fund. For the purpose of defraying the expenses of the organization of the district, and of the care, operation, management, repair, and improvement of such portions of said canal and works as are completed and in use, including salaries of officers and employés, the board may either fix rates of tolls and charges, and collect the same from all persons using said canal for irrigation and other purposes, or they may provide for the payment of said expenditures by a levy of assessments therefor, or by both said tolls and assessments; if by the latter method, such levy shall be made on the completion and equalization of the assessment roll, and the board shall have the same powers and functions for the purposes of said levy as are now possessed by boards of supervisors in this State. The procedure for the collection of assessments by such levy shall in all respects conform to the provisions of this act relating to the payment of principal and interest of bonds herein provided for.

SEC. 38. The board of directors shall have power to construct the said works across any stream of water, water-course, street, avenue, highway, railway, canal, ditch, or flume which the route of said canal or canals may intersect or cross, in such manner as to afford security for life and property; but said board shall restore the same, when so crossed or intersected, to its former state as near as may be, or in a sufficient manner not to have impaired unnecessarily its usefulness; and every company whose railroad shall be intersected or crossed by said works, shall unite with said board in forming said intersections and crossings, and grant the privileges aforesaid; and if such railroad company and said board, or the owners and controllers of the said property, thing, or franchise so to be crossed, can not agree upon the amount to be paid therefor, or the points or the manner of said crossings or intersections, the same shall be ascertained and determined in all respects as is herein provided in respect to the taking of land. The right of way is hereby given, dedicated, and set apart, to locate, construct, and maintain said works over and through any of the lands which are now, or may be, the property of this State; and also there is given, dedicated and set apart, for the uses and purposes aforesaid, all waters and water rights belonging to this State within the district.

SEC. 39. The board of directors shall each receive four dollars per day, and mileage at the rate of twenty cents per mile, in attending meetings, and actual and necessary expenses paid while engaged in official business under the order of the board. The board shall fix the compensation to be paid to the other officers named in the act, to be paid out of the treasury of the district: *Provided*, That said board shall, upon the the petition of at least fifty, or a majority of the freeholders within such district therefor, submit to the electors at any general election a schedule of salaries and fees to be paid hereunder. Such petition must be presented to the board twenty days prior to a general election, and the result of such election shall be determined and declared in all respects as other elections are determined and declared under this act.

SEC. 40. No director or any other officer named in this act shall in any manner be interested, directly or indirectly, in any contract awarded or to be awarded by the board, or in the profits to be derived therefrom; and for any violation of this provision, such officer shall be deemed guilty of a misdemeanor, and such conviction shall work a forfeiture of his office, and he shall be punished by a fine not exceeding five hundred dollars, or by imprisonment in the county jail not exceeding six months, or by both such fine and imprisonment.

SEC. 41. The board of directors may, at any time, when in their judgment it may be advisable, call a special election, and submit to the qualified electors of the district the question whether or not a special assessment shall be levied for the purpose of raising money to be applied to any of the purposes provided in this act. Such election must be called upon the notice prescribed, and the same shall be held, and the result thereof determined and declared in all respects in conformity with the provisions of section fifteen of this act. The notice must specify the amount of money proposed to be raised, and the purpose for which it is intended to be used. At such elections the ballots shall contain the words, "Assessment—yes," or "Assessment—no." If two-thirds or more of the votes cast are "Assessment—yes," the board shall, at the time of the annual levy hereunder, levy an assessment sufficient to raise the amount voted. The rate of assessment shall be ascertained by deducting fifteen per cent. for anticipated delinquencies from the aggregate assessed value of the property in the district as it appears on the assessment roll for the current year, and then dividing the sum voted by the remainder of such aggregate assessed value. The assessments so levied shall be computed and entered on the assessment roll by the secretary of the board, and collected at the same time and in the same manner as other assessments provided for herein; and when collected shall be paid into the district treasury for the purposes specified in the notice of such special election.

SEC. 42. The board of directors, or other officers of the district, shall have no power to incur any debt or liability whatever, either by issuing bonds, or otherwise, in excess of the express provisions of this act, and any debt or liability incurred, in excess of such express provisions, shall be and remain absolutely void.

SEC. 43. In case the volume of water in any stream or river shall not be sufficient to supply the continual wants of the entire country through which it passes, and susceptible of irrigation therefrom, then it shall be the duty of the water commissioners, constituted as hereinafter provided, to apportion, in a just and equitable proportion, a certain amount of said water upon certain or alternate weekly days to different localities, as they may, in their judgment, think best for the interest of all parties concerned, and with due regard to the legal and equitable rights of all. Said water commissioners shall consist of the chairman of the board of directors of each of the districts affected.

SEC. 44. It shall be the duty of the board of directors to keep the water flowing through the ditches under their control to the full capacity of such ditches in times of high water.

SEC. 45. Navigation shall never in anywise be impaired by the operation of this

act, nor shall any vested interest in or to any mining water rights or ditches, or in or to any water or water rights, or reservoirs or dams now used by the owners or possessors thereof in connection with any mining industry, or by persons purchasing or renting the use thereof, or in or to any other property now used directly or indirectly in carrying on or promoting the mining industry, ever be affected by or taken under its provisions save and except that rights of way may be acquired over the same.

SEC. 46. None of the provisions of this act shall be construed as repealing or in anywise modifying the provisions of any other act relating to the subject of irrigation or water commissioners. Nothing herein contained shall be deemed to authorize any person or persons to divert the waters of any river, creek, stream, canal, or ditch from its channel to the detriment of any person or persons having any interest in such river, creek, stream, canal, or ditch, or the waters therein, unless previous compensation be ascertained and paid therefor under the laws of this State authorizing the taking of private property for public uses.

SEC. 47. This act shall take effect immediately.

Approved March 7, 1887.

CHAPTER XIX. An act to amend sections ten, twenty-two, and twenty-seven of an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, relating to appointments to office in case of vacancies, and to assessments of real property, and to the collection of such assessments.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. Section ten of said act is hereby amended to read as follows:

Section 10. The secretary of the board of directors must, as soon as the result is declared, enter in the records of such board a statement of such result, which statement must show—

First. The whole number of votes cast in the district and in each division of the district.

Second. The names of the persons voted for.

Third. The office to fill which each person was voted for.

Fourth. The number of votes given in each precinct to each of such persons.

Fifth. The number of votes given in each division for the office of director, and the number of votes given in the district for the offices of assessor, collector, and treasurer.

The board of directors must declare elected the persons having the highest number of votes given for each office. The secretary must immediately make out and deliver to such person a certificate of election, signed by him and authenticated with the seal of the board. In case of the vacancy in the office of assessor, collector, or treasurer the vacancy shall be filled by appointment of the board of directors. In case of a vacancy in the office of director the vacancy shall be filled by appointment by the board of supervisors of the county where the office of such board of directors is situated from the division in which the vacancy occurred. An officer appointed as above provided shall hold his office until the next regular election for said disirict, and until his successor is elected and qualified.

SEC. 2. Section twenty-two of said act is hereby amended to read as follows:

Section 22. The board of directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds, and at the expiration of ten years after the issuing of bonds by the board must increase said assessment for the ensuing ten years in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent.; for the twelfth year, six per cent.; for the thirteenth year, seven per cent.; for the fourteenth year eight per cent.; for the fifteenth year, nine per cent.; for the sixteenth year, ten per-cent.; for the seventeenth year, eleven per cent.; for the eighteenth year, thirteen per cent.; for the nineteenth year, fifteen per cent.; and for the twentieth year, a percentage sufficient to pay off said bonds. The secretary of the board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment on the property therein enumerated. When collected the assessment shall be paid into the district treasury, and shall constitute a special fund, to be called the "bond fund of ——— irrigation district." In case of the neglect or refusal of the board of directors to cause such assessment and levy to be made as in this act provided, then the assessment of property made by the county assessor and the State board of equalization shall be adopted and shall be the basis of assessments for the district, and the board of supervisors of the county in which the office of the board of directors is situated shall cause an assessment roll for said district to be prepared, and shall make the levy required by this act in the same

manner and with like effect as if the same had been made by said board of directors, and all expenses incident thereto shall be borne by such district. In case of the neglect or refusal of the collector or treasurer of the district to perform the duties imposed by law, then the tax collector and treasurer of the county in which the office of the board of directors is situated must, respectively, perform such duties, and shall be accountable therefor upon their official bonds as in other cases.

SEC. 3. Section twenty-seven of said act is hereby amended to read as follows:

Section 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the collector, prior to the sale, what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock a. m. the following day the property on the next sale day must be resold for the assessments and costs. But in case there is no purchaser in good faith for the same on the first day that the property is offered for sale, then, when the property is offered thereafter for sale and there is no purchaser in good faith for the same, the whole amount of the property assessed shall be struck off to the irrigation district within which such lands are situated as the purchaser, and the duplicate certificate delivered to the treasurer of the district and filed by him in his office. No charge shall be made for the duplicate certificate where the district is the purchaser, and, in such case, the collector shall make an entry, "sold to the district," and he shall be credited with the amount thereof in his settlement. An irrigation district, as a purchaser at such sale, shall be entitled to the same rights as a private purchaser, and the title so acquired by the district, subject to the right of redemption herein provided, may be conveyed by deed, executed and acknowledged by the president and secretary of said board: *Provided*, That authority to so convey must be conferred by resolution of the board, entered on its minutes, fixing the price at which such sale may be made, and such conveyance shall not be made for a less sum than the reasonable market value of such property. After receiving the amount of assessments and costs the collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the names of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the collector, and one copy delivered to the purchaser and the other filed in the office of the county recorder of the county in which the land is situated.

SEC. 4. This act shall take effect from and after its passage.

Approved February 16, 1889.

CHAPTER XX. An act amendatory of and supplemental to an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, and providing for a change of the boundaries of irrigation districts, by including other lands therein.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The boundaries of any irrigation district now or hereafter organized under the provisions of an act, entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March 7, 1887, may be changed in the manner herein prescribed; but such change of the boundaries of the district shall not impair or affect its organization, or its rights in or to property, or any of its rights or privileges of whatsoever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made.

SEC. 2. The holder or holders of title, or evidence of title, representing one-half or more of any body of lands adjacent to the boundary of an irrigation district, which are contiguous, and which, taken together, constitute one tract of land, may file with the board of directors of said district a petition in writing, praying that the boundaries of said district may be so changed as to include therein said lands. The petition shall describe the boundaries of said parcel or tract of land, and shall also describe the boundaries of the several parcels owned by the petitioners, if the petitioners be the owners, respectively, of distinct parcels, but such descriptions need not be more *particular* than they are required to be when such lands are entered by the county *assessor in the* assessment book. Such petition must contain the assent of the peti-

tioners to the inclusion within said district of the parcels or tracts of land described in the petition, and of which said petition alleges they are respectively the owners; and it must be acknowledged in the same manner that conveyances of land are required to be acknowledged.

SEC. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be given and published in the same manner and for the same time that notices of special elections for the issue of bonds are required by said act to be published. The notice shall state the filing of such petition and the names of the petitioners, a description of the lands mentioned in said petition, and the prayer of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district to appear at the office of said board at a time named in said notice and show cause in writing, if any they have, why the change in the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice. The petitioners shall advance to the secretary sufficient money to pay the estimated costs of all proceedings under this act.

SEC. 4. The board of directors, at the time and place mentioned in the said notice, or at such other time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition, and all the objections thereto, presented in writing by any person showing cause as aforesaid why said proposed change of the boundaries of the district should not be made. The failure by any person interested in said district, or in the matter of the proposed change of its boundaries, to show cause, in writing, as aforesaid, shall be deemed and taken as an assent on his part to a change of the boundaries of the district as prayed for in said petition, or to such a change thereof as will include a part of said lands. And the filing of such petition with said board, as aforesaid, shall be deemed and taken as an assent on the part of each and all of such petitioners to such a change of said boundaries that they may include the whole or any portion of the lands described in said petition.

SEC. 5. The board of directors, to whom such petition is presented, may require as a condition precedent to the granting of the same, that the petitioners shall severally pay to such district such respective sums, as nearly as the same can be estimated (the several amounts to be determined by the board), as said petitioners or their grantors would have been required to pay to such district as assessments had such lands been included in such district at the time the same was originally formed.

SEC. 6. The board of directors, if they deem it not for the best interests of the district that a change of its boundaries be so made as to include therein the lands mentioned in the petition, shall order that the petition be rejected. But if they deem it for the best interests of the district that the boundaries of said district be changed, and if no person interested in said district or the proposed change of its boundaries shows cause in writing why the proposed change should not be made, or if, having shown cause, withdraws the same, the board may order that the boundaries of the district be so changed as to include therein the lands mentioned in said petition, or some part thereof. The order shall describe the boundaries as changed, and shall also describe the entire boundaries of the district as they will be after the change thereof as aforesaid is made; and for that purpose the board may cause a survey to be made of such portions of such boundary as is deemed necessary.

SEC. 7. If any person interested in said district, or the proposed change of its boundaries, shall show cause, as aforesaid, why such boundaries should not be changed, and shall not withdraw the same, and if the board of directors deem it for the best interest of the district that the boundaries thereof be so changed as to include therein the lands mentioned in the petition, or some part thereof, the board shall adopt a resolution to that effect. The resolution shall describe the exterior boundaries of the lands which the board are of the opinion should be included within the boundaries of the district when changed.

SEC. 8. Upon the adoption of the resolution mentioned in the last preceding section, the board shall order that an election be held within said district to determine whether the boundaries of the district shall be changed as mentioned in said resolution; and shall fix the time at which such election shall be held, and cause notice thereof to be given and published. Such notice shall be given and published, and such election shall be held and conducted, the returns thereof shall be made and canvassed, and the result of the election ascertained and declared, and all things pertaining thereto conducted in the manner prescribed by said act in case of a special election to determine whether bonds of an irrigation district shall be issued. The ballots cast at said election shall contain the words "For change of boundary," or "Against change of boundary," or words equivalent thereto. The notice of election shall describe the proposed change of the boundaries in such manner and terms that it can readily be traced.

SEC. 9. If at such election a majority of all the votes cast at said election shall be against such change of the boundaries of the district, the board shall order that said

petition be denied, and shall proceed no further in that matter. But if a majority of such votes be in favor of such change of the boundaries of the district, the board shall thereupon order that the boundaries be changed in accordance with said resolution adopted by the board. The said order shall describe the entire boundaries of said district, and for that purpose the board may cause a survey of such portions thereof to be made as the board may deem necessary.

SEC. 10. Upon a change of the boundaries of a district being made, a copy of the order of the board of directors ordering such change, certified by the president and secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon the district shall be and remain an irrigation district, as fully and to every intent and purpose as if the lands which are included in the district by the change of the boundaries, as aforesaid, had been included therein at the original organization of the district.

SEC. 11. Upon the filing of the copies of the order, as in the last preceding section mentioned, the secretary shall record in the minutes of the board the petition aforesaid; and the said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the petition.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this state, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being thereunto authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act mentioned, why the boundaries of the district should not be changed.

SEC. 13. In case of the inclusion of any land within any district by proceedings under this act, the board of directors must, at least thirty days prior to the next succeeding general election, make an order redividing such district into five divisions, as nearly equal in size as may be practicable, which shall be numbered First, Second, Third, Fourth, and Fifth, and one director shall thereafter be elected by each division. For the purposes of elections the board of directors must establish a convenient number of election precincts in said districts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board may deem necessary.

SEC. 14. This act shall take effect from and after is passage.

Approved February 16, 1889.

CHAPTER XXI. An act amendatory of and supplemental to an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, one thousand eight hundred and eighty-seven, providing for the exclusion of certain lands within any such district.

The People of the State of California, represented in Senate and Assembly, do enact as follows:

SECTION 1. The boundaries of any irrigation district, now or hereafter organized under the provisions of an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, one thousand eight hundred and eighty-seven, may be changed, and tracts of land which were included within the boundaries of such district, at or after its organization under the provisions of said act, may be excluded therefrom, in the manner herein prescribed; but neither such change of the boundaries of the district, nor such exclusion of lands from the district, shall impair or affect its organization, or its right in or to property, or any of its rights or privileges, of whatever kind or nature; nor shall it affect, impair, or discharge any contract, obligation, lien, or charge for or upon which it was or might become liable or chargeable had such change of its boundaries not been made, or had not any land been excluded from the district.

SEC. 2. The owner or owners in fee of one or more tracts of land which constitute a portion of an irrigation district, may file with the board of directors of the district a petition, praying that such tracts and any other tracts contiguous thereto may be excluded and taken from said district. The petition shall describe the boundaries of the land which the petitioners desire to have excluded from the district, and also the lands of each of such petitioners, which are included within such boundaries; *but the* description of such lands need not be more particular or certain than is re*quired when the lands* are entered in the assessment book by the county assessor. *Such petition must* be acknowledged in the same manner and form as is required in

case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance.

SEC. 3. The secretary of the board of directors shall cause a notice of the filing of such petition to be published for at least two weeks in some newspaper published in the county where the office of the board of directors is situated, and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of said counties; or if no newspaper be published therein, then by posting such notice for the same time in at least three public places in said district, and, in case of the posting of said notices, one of said notices must be so posted on the lands proposed to be excluded. The notice shall state the filing of such petition; the names of the petitioners; a description of the lands mentioned in said petition, and the prayer of said petition; and it shall notify all persons interested in or that may be affected by such change of the boundaries of the district, to appear at the office of said board at a time named in said notice, and show cause in writing, if any they have, why the change of the boundaries of said district, as proposed in said petition, should not be made. The time to be specified in the notice at which they shall be required to show cause shall be the regular meeting of the board next after the expiration of the time for the publication of the notice.

SEC. 4. The board of directors, at the time and place mentioned in the notice, or at the time or times to which the hearing of said petition may be adjourned, shall proceed to hear the petition and all objections thereto presented in writing by any person showing cause as aforesaid why the prayer of said petition should not be granted. The failure of any person interested in said district to show cause in writing why the tract or tracts of land mentioned in said petition should not be excluded from said district, shall be deemed and taken as an assent by him to the exclusion of such tract or tracts of land, or any part thereof, from said district; and the filing of such petition with such board, as aforesaid, shall be deemed and taken as an assent by each and all of such petitioners to the exclusion from such district of the lands mentioned in the petition, or any part thereof.

SEC. 5. The board of directors, if they deem it not for the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from said district, shall order that said petition be denied; but if they deem it for the best interests of the district that the lands mentioned in the petition, or some portion thereof, be excluded from the district, and if no person interested in the district show cause in writing why the said lands, or some portion thereof, should not be excluded from the district, or if, having shown cause, withdraws the same, and also, if there be no outstanding bonds of the district, then the board may order that the lands mentioned in the petition, or some defined portion thereof, be excluded from the district.

SEC. 6. If there be outstanding bonds of the district, then the board may adopt a resolution to the effect that the board deems it to the best interest of the district that the lands mentioned in the petition, or some portion thereof, should be excluded from the district. The resolution shall describe such lands so that the boundaries thereof can readily be traced. The holders of such outstanding bonds may give their assent in writing to the effect that they severally consent that the board may make an order by which the lands mentioned in the resolution may be excluded from the district. The assent must be acknowledged by the several holders of such bonds in the same manner and form as is required in case of a conveyance of land, and the acknowledgment shall have the same force and effect as evidence as the acknowledgment of such conveyance. The assent shall be filed with the board, and must be recorded in the minutes of the board; and said minutes, or a certified copy thereof, shall be admissible in evidence with the same effect as the said assent; but if such assent be not filed, the board shall deny and dismiss said petition.

SEC. 7. If the assent aforesaid of the holders of said bonds be filed and entered of record as aforesaid, and if there be objections presented by any person showing cause as aforesaid, which have not been withdrawn, then the board may order an election to be held in said district to determine whether an order shall be made excluding said land from the district as mentioned in said resolution. The notice of such election shall describe the boundary of all lands which it is proposed to exclude, and such notice shall be published for at least two weeks prior to such election in a newspaper published within the county where the office of the board of directors is situated; and if any portion of such territory to be excluded lie within another county or counties, then said notice shall be so published in a newspaper published within each of such counties. Such notice shall require the electors to cast ballots which shall contain the words "For Exclusion," or "Against Exclusion," or words equivalent thereto. Such election shall be conducted in accordance with the general election laws of the State: *Provided*, That no particular form of ballot shall be required.

SEC. 8. If at *such election a majority* of all the votes cast shall be against the

exclusion of said lands from the district, the board shall deny and dismiss said petition and proceed no further in said matter; but if a majority of such votes be in favor of the exclusion of said lands from the district the board shall thereupon order that the said lands mentioned in said resolution be excluded from the district. The said order shall describe the boundaries of the district should the exclusion of the said lands from said district change the boundaries of the district, and for that purpose the board may cause a survey to be made of such portions of the boundaries as the board may deem necessary.

SEC. 9. Upon the entry in the minutes of the board of any of the orders hereinbefore mentioned a copy thereof, certified by the president and the secretary of the board, shall be filed for record in the recorder's office of each county within which are situated any of the lands of the district, and thereupon said district shall be and remain an irrigation district as fully, to every intent and purpose, as it would be had no change been made in the boundaries of the district, or had the lands excluded therefrom never constituted a portion of the district.

SEC. 10. If the lands excluded from any district under this act shall embrace the greater portion of any division or divisions of such district, then the office of director for such division or divisions shall become and be vacant at the expiration of ten days from the final order of the board, under section eight of this act, excluding said lands, and such vacancies shall be filled by appointment by the board of supervisors of the county where the office of such board is situated from the district at large. A director appointed as above provided shall hold his office until the next regular election for said district and until his successor is elected and qualified.

SEC. 11. At least thirty days before the next general election of such district the board of directors thereof shall make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered first, second, third, fourth, and fifth, and one director shall be elected by each division. For the purposes of elections in such district the said board of directors must establish a convenient number of election precincts, and define the boundaries thereof, which said precincts may be changed from time to time, as the board of directors may deem necessary.

SEC. 12. A guardian, an executor, or an administrator of an estate, who is appointed as such under the laws of this State, and who, as such guardian, executor, or administrator, is entitled to the possession of the lands belonging to the estate which he represents, may, on behalf of his ward or the estate which he represents, upon being thereto properly authorized by the proper court, sign and acknowledge the petition in this act mentioned, and may show cause, as in this act provided, why the boundaries of the district should not be changed.

SEC. 13. In case of the exclusion of any lands under the provisions of this act, there shall be refunded to any and all persons who have paid any assessment or assessments to such district, or any lands so excluded, any sum or sums so paid. Such payments shall be made in the same manner as other claims against such district, and from such fund or funds as the board of directors may designate.

SEC. 14. This act shall take effect from and after its passage.

Approved February 16, 1889.

CHAPTER CLXXVIII. An act supplemental to an act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, eighteen hundred and eighty-seven, and to provide for the examination, approval, and confirmation of proceedings for the issue and sale of bonds issued under the provisions of said act.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The board of directors of an irrigation district now or hereafter organized under the provisions of the act entitled "An act to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes," approved March seventh, eighteen hundred and eighty-seven, may commence a special proceeding, in and by which the proceedings of said board and of said district providing for and authorizing the issue and sale of the bonds of said district, whether said bonds or any of them have or have not then been sold, may be judicially examined, approved, and confirmed.

SEC. 2. The board of directors of the irrigation district shall file in the superior court of the county in which the lands of the district or some portion thereof are *situated* a petition praying, in effect, that the proceedings aforesaid may be *examined, approved*, and confirmed by the court. The petition shall state the facts *showing* the proceedings had for the issue and sale of said bonds, and shall state gen-

orally that the irrigation district was duly organized, and that the first board of directors was duly elected; but the petition need not state the facts showing such organization of the district, or the election of said first board of directors.

SEC. 3. The court shall fix the time for the hearing of said petition, and shall order the clerk of the court to give and publish a notice of the filing of said petition. The notice shall be given and published in the same manner and for the same length of time that the notice of a special election provided for by said act to determine whether the bonds of said district shall be issued is required to be given and published. The notice shall state the time and place fixed for the hearing of the petition and the prayer of the petition, and that any person interested in the organization of said district, or in the proceedings for the issue or sale of said bonds, may, on or before the day fixed for the hearing of said petition, demur to or answer said petition. The petition may be referred to and described in said notice as the petition of the board of directors of —— irrigation district (giving its name), praying that the proceedings for the issue and sale of the bonds of said district may be examined, approved, and confirmed by said court.

SEC. 4. Any person interested in said district, or in the issue or sale of said bonds, may demur to or answer said petition. The provisions of the code of civil procedure respecting the demurrer and the answer to a verified complaint shall be applicable to a demurrer and answer to said petition. The persons so demurring to or answering said petition shall be the defendants to said special proceeding, and the board of directors shall be the plaintiff. Every material statement of the petition not specifically controverted by the answer must, for the purpose of said special proceeding, be taken as true, and each person failing to answer the petition shall be deemed to admit as true all the material statements of the petition. The rules of pleading and practice provided by the code of civil procedure which are not inconsistent with the provisions of this act are applicable to the special proceeding herein provided for. A motion for a new trial must be made upon the minutes of the court. The order granting a new trial must specify the issues to be re-examined on such new trial, and the findings of the court upon the other issues shall not be affected by such order granting a new trial.

SEC. 5. Upon the hearing of such special proceeding the court shall have power and jurisdiction to examine and determine the legality and validity of, and approve and confirm, each and all of the proceedings for the organization of said district under the provisions of the said act, from and including the petition for the organization of the district, and all other proceedings which may affect the legality or validity of said bonds, and the order for the sale, and the sale thereof. The court, in inquiring into the regularity, legality, or correctness of said proceedings, must disregard any error, irregularity, or omission which does not affect the substantial rights of the parties to said special proceeding; and it may approve and confirm such proceedings in part, and disapprove and declare illegal or invalid other and subsequent parts of the proceedings. The court shall find and determine whether the notice of the filing of said petition has been duly given and published for the time and in the manner in this act prescribed. The costs of the special proceedings may be allowed and apportioned between all the parties, in the discretion of the court.

SEC. 6. An appeal from an order granting or refusing a new trial, or from the judgment, must be taken by the party aggrieved within ten days after the entry of said order or said judgment.

SEC. 7. This act shall take effect and be in force from and after its passage.

Approved March 16, 1889.

STATEMENT OF A. C. FISH.

The CHAIRMAN. The committee will be glad to hear anything you desire to say bearing on the subject of irrigation.

Mr. FISH. I would be wholly unwilling to keep this committee a moment longer than would be necessary except to call your attention to the fact that when you get over the Tehachapi Mountains we will show you in Los Angeles County a region of 250,000 acres of irrigable land—150,000 acres already irrigated—sustaining a population of 113,000 persons, which ten years ago sustained a population of only 30,000. We will show you irrigating ditches 1,500 miles in length.

The CHAIRMAN. You mean ditches aggregating that in mileage?

Mr. FISH. Yes; we will show you all sorts of ditches, from the old Mexican kind up to *iron pipe* under ground, of which we have about 400

miles, and we will show you a region of country which presents an object lesson in irrigation, and which I think will be a very convincing argument in favor of the grand project which the Government is now investigating.

Something has been stated here of the necessary duty of water in southern California. I have an instance in point. In 1887 I bought of the Precipice Water Company, in the San Gabriel Valley, 68 shares of water, the whole number of shares being 12,500. Mr. William Hammond Hall, in his late report, states that they have 40 miner's inches of water. The market price of those shares was $50 each. Only a little was for sale. It was owned by four individuals. I will not give their names. As I say, but a little of it was for sale at $50 a share. Soon it went up. I had purchased the land and I must have water for it. The land was not worth one-half the sum I paid for it unless I could get water, although it is worth $1,000 an acre to-day. The total of water was 18,750 miner's inches. The people of that whole valley from Pasadena to Colton and Riverside are thirsting for water. My friend, Mr. Holt here, states that the valuable reservoirs are all taken up.

Mr. HOLT. I said the main reservoir sites were on private land, not on public land.

Mr. FISH. Yes. The field for surveys which will point out the practical sites for reservoirs, is one that you will find a very interesting one in that valley. I have taken the statements of twenty-one persons, who have furnished their names for publication, in San Bernardino and Los Angeles Counties, as to the products of their orange orchards. I asked them: "What does your orange orchard produce on three-year old cuttings, one year grafted?" Eleven replied that they had averaged at the end of four years $419 per acre each.

The CHAIRMAN. Per annum?

Mr. FISH. Yes; per annum. Those statements can be verified under oath. If you want an object lesson which will give you a view of irrigable land go to one of those orange farms and you will see that from within the orange farm you can throw a stone into a cactus patch that is not worth a dollar an acre, while the orange orchard is cheap at $1,000 an acre.

When you consider the statements made by this State Board of Trade that west of the one hundredth meridian we have a quantity of land that is sufficient to support a population of 60,000,000, you can realize that the responsibilities of this committee are very great. You are charged with an important mission, and we ask you not only to see Fresno, but to go over the Tehachapi Mountains down into the southland and see what talismanic effect the water has had upon what is otherwise a desert.

If that writer is correct who states that he is a public benefactor who makes two blades of grass to grow where only one grew before, you have it in your power, gentlemen, to become public benefactors in the grandest sense.

Mr. ESTEE. The State Board of Trade represents all the industrial interests of California. Its committee has now presented to you their printed report and such witnesses as they have brought here. They have endeavored to present for your consideration facts in their report which they think will upon examination prove instructive. They have brought before you many leading representatives of the several industries—gentlemen who have come from all parts of the State to give *you their reasons* why they are in favor of irrigation in California. If *you gentlemen* do not desire to hear any others, we will submit what we

have already done. For myself, I am content to say to you that we are more than grateful for the attention you have given to the people of this State on this most important question.

The CHAIRMAN. We are much obliged to the State Board of Trade for the pains they have taken to gather together the gentlemen who have given us the valuable information which we have had to-day. There are a few other gentlemen who are here who have come to be heard, and we will now hear them.

STATEMENT OF WILLIAM CARTER, OF SAN DIEGO.

The CHAIRMAN. We shall be glad to hear anything that you desire to say to the committee with regard to irrigation in your section.

Mr. CARTER. With other gentlemen now present I have come here on short notice. We have come as the representatives of the Chamber of Commerce of San Diego, for the purpose of meeting this committee on the inception of its work in this State. We are not prepared to submit any special feature of the subject, but to interest the committee in the work of irrigation, and to extend in connection with our friends from Los Angeles County the thanks of the people of southern California for the work the committee is doing. We hope to be able to show you gentlemen what has been done throughout the counties of San Bernardino and Los Angeles. We can show you a storage reservoir 90 feet high, and can show you all that has been done in our county.

Senator JONES. How large is the reservoir of which you speak?

Mr. CARTER. It covers 700 acres in area. The dam is 90 feet high.

Senator JONES. What is the depth?

Mr. CARTER. I am not prepared to say what the average depth is, but at the dam it is 90 feet high.

Senator JONES. They used water from it during the irrigating season of last year?

Senator JONES. Do you know what it cost?

Mr. CARTER. I think about $200,000, or over.

STATEMENT OF F. H. CUNNINGHAM, OF SAN DIEGO.

The CHAIRMAN. What have you to say in regard to irrigation?

Mr. CUNNINGHAM. I would say that the water in the reservoir, which has just been referred to by Mr. Carter, is 70 feet high, and that when the water is up to the level of the 70 foot mark the reservoir holds 6,000,000,000 gallons of water. The dam itself cost something over $200,000, and the pipe line leading from it cost $750,000, making a total expenditure of about $1,000,000. The land which it is to cover comprises about 20,000 acres of mesa, which before the work was attempted, was utterly worthless for horticulture or any use whatever. The land is now being sold for $350; that price being somewhat influenced by the fact of the proximity of the city of San Diego.

We have also another work there which brings the water from a distance of 20 miles from the mountains to the city of San Diego. This water is brought in a wooden flume, which is somewhat unique for that purpose in that part of the State. This flume may, by those who wish, be traversed in a boat. The may ride on the surface of the water 35 miles on that *conduit*. *Those* two systems I think are systems that you

will not see anywhere else—a great storage dam in the form of a seg ment of a circle and a great wooden flume used for the purpose of irrigation.

Senator JONES. Does that flume supply water to the city of San Diego?

Mr. CUNNINGHAM. Yes.

Senator JONES. The city takes no water from the dam?

Mr. CUNNINGHAM. No.

Senator JONES. The reservoir is used for irrigation alone?

Mr. CUNNINGHAM. Yes. This wooden flume is supplied with water from a reservoir located 60 miles from the city; that has a dam 25 feet high.

Senator JONES. The reservoir of which you speak then does not supply water to the city at all?

Mr. CUNNINGHAM. Not to the city of San Diego, but it does to National City.

Senator JONES. Do the projectors of this work own the 20,000 acres of land that you say are reclaimed?

Mr. CUNNINGHAM. They own a large part of it. It was given to the Santa Fé Railroad as an inducement to bring the road to San Diego.

STATEMENT OF JOHN ROTH, OF TULARE CITY.

The CHAIRMAN. What have you to say with regard to irrigation in your section?

Mr. ROTH. My colleague and myself have been sent up here to represent the people of one or two of, I think, the driest counties in the State. I have not prepared any statement. My colleague, who is with me, has some statistics to present, and the record would probably be more interesting to you than any oral statement I might make. I will, however, simply say that we have an extremely slight rain-fall. We think this committee should stop on its way south to give us an opportunity to show what we have done with the little rain-fall we get. There is considerable water in that country, but it is absolutely necessary that we build up some kind of storage system in order to develop that country.

STATEMENT OF JOHN TUOHY, OF VISALIA, TULARE COUNTY.

The CHAIRMAN. State to the committee your views regarding irrigation in your section.

Mr. TUOHY. I have no statistics to give you here, but the place we represent has prepared an address, giving the catchment area of Tulare County and the necessity of reservoirs. On the part of the board of trade and all our county, we desire you to visit the town or county of Tulare, and see this for yourselves. We will endeavor to show you the amount of fertile land we have there and the large number of people it will sustain over and above those there who could be supported without it. We can assure the committee that the people will be glad to see you. They are extremely pleased to know that this inquiry has been set on foot. We earnestly ask you to call upon us there, and let us know when you will be there, so we can invite our people to meet you *and show* you what they have.

STATEMENT OF J. H. WALLACE, OF SAN FRANCISCO.

In the two great valleys of California—the San Joaquin and Sacramento—water is obtained from wells usually from 75 feet to 200 feet in depth. In most parts of these valleys a supply of from 2,000 to 3,000 gallons per hour can be obtained from a bored well 7 inches in diameter.

In crossing the Sierra Nevadas on the Central Pacific Railroad water is obtained from the many streams which are fed by the melting snows, and thus have water running in them throughout the year.

Advantage has been taken of the numerous ditches and canals built in earlier times to supply the mines with water, and which are now being largely used to supply water for irrigation. There being many of these canals close to the line of the road, and at elevations sufficient to run water to our tanks by gravity, we have arranged with the owners of them to furnish us with the water needed. This is the case at all our water stations between Rocklin, which is the foot of the mountains, and Alta, at an elevation of 3,607 feet. Between this point and Truckee, on the eastern side of the mountains, the company has appropriated the flow of springs and small streams. A small lake, known as Crystal Lake, is drawn on for a supply at a station of the same name. And at Summit Station water is obtained from another small lake.

Between Truckee and Wadsworth the road follows the Truckee River, which furnishes the water used between these two points. The Truckee River is left at Wadsworth, and between that station and Lovelock's, at which point the Humboldt River is reached, we have been unable to get any water.

A well was put down several years ago at White Plains, a station close to what is known as the Sink of the Humboldt; this well was bored to a depth of 2,300 feet without striking any water, and was then abandoned.

Between Lovelock's and Ogden the country has been very thoroughly prospected for springs large enough to supply the road with water, and wherever such have been found they have been appropriated for that use, the water being conveyed to the railroad by pipe-lines from 1 to 9 miles in length. Where water could not be obtained in this manner it has been pumped from wells. One of these is at Battle Mountain, where the supply was formerly obtained from a small spring about 3 miles distant; but about two years ago, this spring not supplying enough water, a well was bored at the station, and at a depth of 180 feet a vein of water was struck which flowed over the pipe at the surface of the ground. This well is 7 inches in diameter, and flows about 11,000 gallons in twenty-four hours. A steam-pump, pumping at the rate of 3,600 gallons an hour, lowers the water only 10 feet.

The last three seasons have been very dry, and but a very small amount of snow has fallen in Utah and Nevada; the result is, that springs which three or four years ago yielded an abundance of water all through the summer have this year been extremely low.

On the Southern Pacific Railroad, crossing the Tehachapi Mountains, between San Francisco and Los Angeles, springs have been developed which yield all the water needed for railroad purposes. East of Los Angeles water is obtained in the same way; there being, however, a few wells from which water is pumped at points where springs could not be found at convenient distances from the road.

At Indio and Walters, two stations on the edge of the Colorado Desert, at elevations respectively of 20 feet and 195 feet below sea-level,

an excellent quality of water is found at a depth of from 75 feet to 100 feet below the surface.

Between Walters and Yuma, a distance of 107 miles, we have been unable to get any water fit for locomotive boilers. At one station, known as Flowing Well, a well was bored to a depth of about 400 feet, and an artesian flow of salt water was struck. Other attempts to obtain water in this neighborhood have been unsuccessful.

East of Yuma the railroad follows the valley of the Gila River to Gila Bend, a distance of 119 miles; and at three stations, viz, Tacna, Texas Hill, and Gila Bend, water is pumped from the river into the tanks at the stations.

At Sentinel, the road being a long distance from the river, a well was bored to a depth of 1,029 feet. At this depth water was struck which rose to 185 feet above the surface. It yields a supply of about 3,000 gallons an hour, although the lower part of the well is only 5 inches in diameter.

Between Gila Bend and El Paso water is obtained altogether by pumping from wells, the wells varying from 100 to 600 feet deep. We have recently completed a well at Lanark which is 950 feet deep. At this depth we believe we have found a good supply of water.

The California and Oregon Railroad, after passing through the Sacramento Valley, enters the cañon of the Sacramento at Redding, and an abundant supply of water is obtained from the numerous small streams flowing into the river.

Passing out of the Sacramento Cañon, around the base of Mount Shasta, the road enters the Shasta Valley, and at Montague water is obtained from a well At Hornbrook, a station a few miles from the crossing of the Klamath River, water is also pumped from a well. At other points, as far north as Ashland, springs in the neighboring hills have been appropriated by the company or purchased from the original proprietors, and a supply of water got from them.

No attempts have ever been made by this company to store water, though there are, doubtless, several places where it would be advantageous to do so.

STATISTICS OF COUNTIES USING IRRIGATION.

Number of ditch systems, mileage thereof, valuation for taxation, acres cultivated in grains, etc., in vines, and fruit-trees growing.

[Compiled from reports of State board of equalization, 1880 to 1888.]

Counties.	No. of systems.	Mileage of ditches.	Average value per mile.	Total valuation.	No. of acres in cultivation, not fruit	Acres in vines.	No. of fruit-trees.
Alameda	1	5	$200.00	$1,000	79,005	3,521	420,560
Alpine	6	14	261.00	3,660	1,660	.....	1,250
Amador	7	107	1,355.00	145,000	30,705	1,075	120,911
Butte	6	171	219.00	37,450	18,754	444	149,412
Calaveras	.....	2	*1,000.00	2,000	31,575	1,440	825,500
Colusa	.....	2	*1,000.00	2,000	432,954	225	126,276
Del Norte	2	13	446.00	5,800	2,679	.....	9,642
El Dorado	.....	27	1,089.00	30,095	13,655	1,715	299,770
Fresno	11	136	1,726.00	234,750	174,908	11,558	351,888
Inyo	2	15	123.00	1,850	10,154	25	23,864
Kern	32	297	6,734.00	†2,000,000	42,000	74	78,000
Lake	.....	2	.....	.....	18,234	1,327	83,448
Lassen	.....	6	1,120.00	6,715	†13,000	.....	.....
Los Angeles‡	.....	345	152.00	52,515	119,900	†27,000	‡1,073,510
Mariposa	.....	33	50.00	1,670	†1,500	67	11,265
Merced	3	86	2,104.50	180,988	322,010	626	81,390
Placer	.....	49	1,089.00	53,699	31,157	2,527	§429,055
Plumas§	.....	55	*103.00	5,715	.....	.....	12,000
Sacramento	4	54	40.00	21,200	158,132	6,528	503,180
San Bernardino†	7	67	6,323.00	423,650	143,526	11,415	1,847,945
Santa Cruz	.....	10	*1,089.00	10,890	1,989	1,326	282,211
San Diego‖	19	.....	.....	†1,500,000	28,480	3,781	191,526
San Mateo ¶	.....	.....	.....	†706,066	20,381	778	31,679
Shasta	2	6	1,000.00	6,100	21,818	.....	82,000
Sierra	.....	2½	1,089.00	2,700	13,710	4	4,820
Siskiyou	.....	370	1,089.00	402,930	48,168	2,360	73,293
Stanislaus	3	13½	2,170.00	29,500	282,983	516	40,000
Tehama	.....	51	386.00	19,680	135,872	2,197	254,696
Trinity	.....	120	68.00	8,175	21,200	200	20,000
Tulare	15	177	323.00	57,650	286,296	3,701	344,102
Tuolumne	4	281	215.00	60,450	5,460	900	15,250
Ventura	5	20	702.00	14,038	83,830	377	382,303
Yolo	4	90	322.00	29,000	157,600	3,600	132,644
Yuba	.....	120	100.00	11,850	128,433	277	74,970
Total	133	2,767	1,089.00	6,077,990	4,777,237	85,623	8,778,360

In the lower foot-hills mining counties a considerable proportion of the mining ditches are also used for irrigating the small farms of that section; probably one-third of the total mining mileage is so used.

The mileage and valuation of the mining ditches of California, as shown by the report of 1887-'88, were as follows: Values, $1,381,831; mileage, $1,591. At least one-fourth of this mileage, taking the mining counties through, do service also for irrigation uses.

* Based on averages shown in other counties.

† Estimated.

‡ The values of irrigation works and appliances in the counties of Los Angeles and San Bernardino are greatly underestimated, as a glance at the evidence will show. At least $2,000,000 should be added for the reservoir (Bear River, etc.), the Ontario piping system, and the artesian wells, which fill so important a place in the economy of California reclamation.

‡ The number of trees in Los Angeles County is taken from the report of 1886.

§ For Plumas County the report of 1887 is used.

‖ San Diego, no return is made of the value for taxable purposes; the estimate given, including valuable reservoirs, flumes, and pipe-systems, is obtained from other sources.

¶ The San Mateo values include the Spring Valley Water Company's plant and works which supply the city of San Francisco.

STATEMENT OF THOMAS HUGHES, OF FRESNO, IN RELATION TO RISE IN REAL ESTATE VALUES.

Having been familiar with the productions of several of the coast counties where no irrigation was needed, and with the prices lands were selling at where the same were planted to vines and tree-fruits, which were from $150 to $300 per acre and even as high as $500, on my arrival ten years since in Fresno I opened a real-estate office for the selling and renting of lands for others. After examining the immense crops of fruits and grapes produced on the irrigated lands, which were fully double that produced in any other county, while in many cases the quality of the production was far superior, I came to the conclusion that the irrigated portion of our county would become very valuable, or as much so as lands producing similar crops in other counties, and as I had no money to buy lands with, I began to look around for some tract on which I could get a contract to purchase without the payment of any cash.

I obtained such a contract on 12,000 acres for six months, the purchase price to be $2 per acre. It was near the railroad station called Fowler, 12 miles south of the town of Fresno, and was to have a commission of 5 per cent. for selling. I spent two months traveling from place to place, urging my friends to look at this tract of land, but failed to get any one to buy. But one man came to look at the land. While we were on the land he stood up in the buggy and looked around and could not even see a sheep cabin. Dropping back into his seat, he made the remark, "Hughes, this is too big a country to ever be settled up." This same man four years after invested over $200,000 in some of the same land, at from $12 to $20 per acre. Since then similar land has been sold as high as $400 per acre. This year, cultivated in raisin-grapes, some of it has paid the owners from $100 to $200 net per acre.

In 1881 I purchased 7,000 acres of land adjoining the town of Fresno, agreeing to pay $40,000, and having 6 months to make the first payment of $5,000. I immediately had circulars printed, offering to sell land, with water for irrigation, to parties who would move on the land and improve in trees and vines, without any cash payment. In this way I soon sold the most of this tract, and would borrow on my note with these mortgage notes as collateral security, getting about 50 cents advance on the dollar. I sold the land at prices ranging from $40 to $75 per acre. This gave me a surplus of money to pay what I was owing on the land, and money to make a small payment on the purchase of other lands, which I continued to do from year to year, until I was myself $350,000 in debt, and had mortgage notes due me to the amount of nearly $500,000 for lands in most cases sold on a credit of one, two, and three years, with interest at 10 per cent., payable half yearly. The settlers have all made their places worth to-day from $200 to $1,000 per acre, and all have paid me in full. I have sold thousands of acres of land on these terms, and I have never been compelled to foreclose a mortgage in Fresno County. Men who will work can settle on irrigated land, pay their 10 per cent. interest, improve the land, and pay for their land at prices ranging from $50 to $125 per acre inside of four years. And that, too, on land that before the irrigation system was started could not be sold for more than from $1 to $5 per *acre*, according to location.

When I came to this county, in 1878 the Central California Colony,

which was first started in 1876 by B. Marks, for W. S. Chapman, was irrigated by water from the Fresno Canal and Irrigation Company. At that time only about 1,000 acres of the colony was under irrigation. Although there was nearly as much water in the canal at that time as at the present, there was a scarcity of water, and Mr. Eisen, who had a vineyard of some 250 acres on the canal, 4 miles above the colony, would tell the intending settlers that there was not water sufficient in King's River to give him all he wanted for his place, to say nothing about water for all the colonies the real-estate agents were laying out.

At that time, in boring wells for family use, it was from 50 to 60 feet to the first water. The constant irrigation, the extent of the land irrigated increasing every year, has brought the water now up to within 6 to 8 feet of the surface. We claim that instead of 1,250 acres that we had to irrigate in order to mature our crops in 1878, over 60,000 acres have become subirrigated and need no irrigation whatever. The vineyards which the sub-committee rode through have never been irrigated since the first year they were planted. It has in hundreds of instances been demonstrated that 10 acres are sufficient for a comfortable support of a family on our irrigated lands. By the expenditure of $10,000,000 in the reservoiring of water in the mountains, and piping a portion to what we call the west side of the San Joaquin Valley, a desert land sufficient to support not less than 5,000,000 people would be reclaimed. It has been demonstrated that no other portion of the world can produce as many pounds of grapes per acre as we can in Fresno County. In fact, everything that is grown from the soil which needs moisture and sunshine grow and produce so abundantly that men do not believe our statements until they see them.

Adjourned.

STATEMENT OF M. C. KING, OF FRESNO COUNTY.

In my opinion 100,000 acres, otherwise irreclaimable, in Fresno County may be brought under use by reaching the underground water supply and bringing the same by appropriate pumps to the surface, thence distributing the same. Average depth of water would be about 75 feet. Fuel costs: Wood, $7 per cord; coal, from $6 to $12 per ton, mined by the farmers themselves. Its market value is from $3 to $3.50 per ton.

Adjourned.

TULARE, CAL., *August* 30, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also, Director Powell.

STATEMENT OF JOHN TOUHY, OF TULARE.

Mr. Chairman and gentlemen, through its committee, Tulare Grange, No. 198, Patrons of Husbandry, California, respectfully desire to address you on the subject of your mission, and ask your particular attention to Tulare County, its adaptability to irrigation, its possible productiveness by means thereof, the sources from which water can be obtained, the means which can be adopted for increasing the supply, the great necessity for systematic work in securing, distributing, and using water for irrigation.

Tulare County is in the southern portion of Tulare Valley. It has an area of 3,835 square miles, or 2,454,400 acres, of mountain and hill land, and 1,775 square miles, or 1,136,000 acres, of valley land. Of the valley land one-third, or about 380,000 acres, as being lake, alkali, river-bed, and such like, may be assumed to be unfit for cultivation, but the remaining 750,000 acres are as rich, fertile, and, under a proper system of irrigation and cultivation, as productive as any equal body of land in the United States.

We believe your honorable committee will have ample statistics and evidence furnished you, and that your own observation will confirm them, as to the great benefit of irrigation in increased production, in increased value of products, in capabilities of sustaining increased population, as also increased wealth to the community and increased security, if not absolute certainty, of regular annual crops. On such points we deem it superfluous and unnecessary for us to dwell, but believing in your investigations you desire to satisfy yourselves not alone on the benefits of irrigation, but also where and why it can be made most efficient, where facilities for obtaining water are best, and quality of soil and atmospheric conditions are such as will conduce to the production of most remunerative and varied crops; in short, where best results can with least expenditure of labor and means be obtained, we ask your favorable consideration to the fertility of our soil, to the variety and value of its products, to the necessities of making them more valuable, to the facilities for obtaining and storing water, to the necessity of aid and system therein, and to our climatic conditions which insure the production and perfection of the most remunerative crops.

Every variety of vegetable, in size, quality, and quantity equal to any part of California, are grown in Tulare County. In fruits, apricots, peaches, raisin grapes, nectarines, figs, pears, prunes, plums (in the mountains, apples), oranges, and lemons are grown to perfection.

These crops, to be produced in their greatest abundance and perfection, must be irrigated. When irrigated, nothing the husbandman can get from his soil is so remunerative.

At the present time the staple product of Tulare County is wheat, for export to Europe, in our county at the present time worth, sacked and delivered at the railroad, $1.05 per 100 pounds. On our dry land, where wheat is cultivated, 320 acres, in consequence of the uncertainty and irregularity of the seasons, is insufficient to support a small American family; whereas, with irrigation, in vegetables and fruits as before mentioned the same family could have all the comforts of a home, in a most liberal acceptation of the word, on 20 acres, and many of those whose experience has enabled them to know assert on 10 acres.

In Tulare County water for irrigation is obtained from White River with, in six years' observation, a mean annual discharge of 90 cubic feet per second; from Deer Creek with a mean annual discharge of 110 cubic feet per second; from Tule River with a mean annual discharge of 451 cubic feet per second; from Kaweah River with a mean annual discharge of 724 cubic feet per second. Kings River, flowing through Fresno County, and in places between Fresno and Tulare Counties, has a mean annual discharge of 2,584 cubic feet per second, the greater portion of which is appropriated and used in Fresno County; still considerable of it is appropriated and used in Tulare County, and 800 cubic feet per second might be appropriated with propriety for Tulare County. This will give in all 2,064 cubic feet per second as a mean annual discharge which can be utilized for irrigation in Tulare County, *added to* which there are about one hundred and fifty flowing wells in

the county capable of irrigating on an average 40 acres to the well. For the above estimates of flow of rivers we are indebted and refer you to ex-State Engineer William Ham Hall's carefully compiled volume of Physical Data and Statistics.

To the foregoing supply of water may be added what may be saved by storage reservoirs, for which purpose State Engineer William Hall reported to the legislature in 1881 that he located one site on Tule River covering 7,164 acres, capable of storing 2,675,000,000 cubic feet; three sites on Kaweah River, 3,885 acres, capable of storing 7,162,000,000 cubic feet, and seven sites on Kings River, covering 1,134 acres, capable of storing 1,665,000,000 cubic feet, the surveying of Kings River in consequence of the lateness of the season having to be abandoned before completion.

The foregoing estimates of water supply being for the whole year, we may say, practically, irrigation is carried on from the 1st of March to 1st of July; before and after those dates but little irrigation is or need be done; still, estimating on the annual discharge of 2,064 cubic feet per second and allowing a duty of water of 1 cubic foot per second per acre per twenty-four hours, which makes allowance of 15 per cent. for percolation and evaporation, we find the 2,064 cubic feet per second is capable of irrigating that number of acres per twenty-four hours, or 241,680 acres in a season of one hundred and twenty days. We hesitate not to say not one-fifth part of that amount is irrigated. Still, if all of it was irrigated this is not all the duty which the water discharge in our county is capable of performing, for we find on reference to Physical Data and Statistics that for the months of March, April, May, and June, and the years 1879, 1880, 1881, 1882, 1883 and 1884, the mean discharge of Kings River was 18,336 cubic feet per second; of Kaweah River 5,958 cubic feet per second; of Tule River 3,500 cubic feet per second; of Deer Creek 537 cubic feet per second, and of White River 325 cubic feet per second, and allowing 6,000 cubic feet per second as Tulare's portion of the flow from Kings River, we have, in all, a flow of 16,330 cubic feet per second, or about eight times the mean annual discharge, and as a matter of sequence capable of irrigating eight times the present amount of land.

Lest your honorable committee should infer from the foregoing that the water is here and we have only to apply it to our lands, in all earnestness we say to you nothing can be more misleading. 'Tis true the water is here, but the system of distribution and use is lacking, and for explanation of cause we refer you to State Engineer William Ham Hall's report to the legislature of 1880.

Without irrigation the best results of agriculture are impossible. Without system of use and distribution the best results of irrigation are impossible.

With a systematic irrigation and with the atmosphere of Tulare and the natural fertility of its soil the possibilities of agriculture in Tulare and in the future can scarcely be imagined.

The drying of fruit and making of raisins have developed into the most successful branch of agriculture, and many successful experiments in that line in Tulare County have proven our soil and climate to be particularly adapted to carrying it on to its greatest perfection, the one great drawback being lack of water to irrigate.

We declare the present system of agriculture pursued in this county, and the only one practicable without irrigation, is vicious. It is injurious alike to present and future generations. Legislation should

discourage it where provision can be made for a better system, or at least should by all laudable means encourage the better system.

We find from tables in Physical Data and Statistics, State engineer's report, that from records kept at five different points in Tulare County the mean annual rain-fall at Goshen for five years was 8.04 inches; at Lemoore, six years, 7.70 inches; at Tulare, ten years, 6.62 inches; at Visalia, five years, 9.14 inches, and at Lewis Valley, five years, 12.39 inches—Lemoore being near the lake and west side of the valley, Lewis Valley being on the east side of the valley in the edge of the foothills—showing a mean annual rain-fall for the county of 8.80 inches.

When we assure you experience has taught us an annual rain-fall of 10 inches, coming at proper intervals, is necessary for a crop you can judge for yourselves how necessary it is to encourage a better system of agriculture and a better class of agricultural products.

We have said the cultivation of vegetables, fruits, and raising grapes are the most profitable branches of agriculture, capable of sustaining the largest amount of population on the smallest amount of land. We have said Tulare County is particularly well adapted to the cultivation and curing of these products, for whilst other counties, particularly along the coast, can grow fruit as well as Tulare, yet from the humidity of the atmosphere in the coast counties and the absence of moisture and the evaporation in the atmosphere of Tulare we can claim it among the best counties in the State for growing and drying fruit.

We believe, then, considering the facilities for perfecting a system of irrigation; considering that in no place can a system of irrigation be adopted and introduced more readily, more cheaply, or more efficiently, that in no way can the General Government better assist the prosperity of the present and future generations than to devise, adopt, and perfect a system of water storage and irrigation for Tulare County, for in no place is it more requisite, more desired, or can be more useful.

In the impartial consideration of this appeal to you, and in considering the claims we make, there is one more factor to which we wish to call your attention. Whilst the General Government is with a lavish hand annually dispensing large sums for the improvement of bays and rivers adjacent to the coast, and to which we necessarily contribute and from which we derive small practical benefit, we, residing 250 miles from the sea-board, solely dependent on a single line of railroad for the transaction of our business and at its mercy as to terms, can not help believing—we do believe—it is right and just that the General Government should take into consideration our location, our situation, and our claims for assistance in a matter in which, we regret to say, we have found we can not so well assist ourselves.

In conclusion we ask you to believe that in making this appeal we do not desire to be obtrusive, but make it because we believe your committee and Congress desire to be informed where good can be done and how it can be accomplished; because we believe your committee and Congress in seeking to build up and benefit the whole community desire to be fair and impartial; because on the line we propose can you best assist this community and promote its best and most material interests, thereby benefiting and building up the whole country of which we are an integral part.

STATEMENT OF JOHN URTON, OF HANFORD, TULARE COUNTY.

The CHAIRMAN. What is your profession?

Mr. URTON. I am a farmer and civil engineer.

The CHAIRMAN. The settlement of Hanford has a very interesting history. Were you among the beginners?

Mr. URTON. I was among the earlier settlers.

The CHAIRMAN. Tell us how they did in Hanford?

Mr. URTON. When we started there we had a dry arid plain, and we were very much discouraged by the stock-raisers. They told us that the water supply was insufficient to accomplish anything by irrigation, and there was a question whether the soil was of that character that it would be benefited by irrigation.

The CHAIRMAN. What time was that?

Mr. URTON. That was in 1873–'74; the earlier settling of the country. We were there and a good many of us had nothing to get away on. As a result we took hold to see what we could accomplish. The situation was such that if we made a failure we would not be hurt much. We made an examination of the Kaweah and Kings Rivers to see where we could best get the water. The people were poor and any engineering plan for them had to be within their reach. There was no use talking about anything which required much money. We had a few beans and some mustangs. With what means we had we made a survey and we found that it was within our reach to introduce water.

The first canal I was connected with was a small ditch from the Kaweah River carrying 75 cubic feet of water per second. That was the original size. We introduced that water and we found that things grew, that we could produce vegetables of all kinds; and we were encouraged to build ditches. The Lakeside ditch was the next ditch built.

The CHAIRMAN. Where was that taken from?

Mr. URTON. From the Kaweah. After we had taken that out there was a ditch started from Kings River called the People's Ditch. These ditches all commenced to distribute their water at the same time. The subject was new to us all, but we grappled with it the best we could.

The CHAIRMAN. Were you farmers?

Mr. URTON. Yes; mostly. We, of course, had to find out what kind of grades our earth would stand, as the soil was porous. We found out how to irrigate, and after that we enlarged these three ditches, and after we had introduced water our population began to increase.

In the course of four or five years from the beginning we irrigated with this water. The People's Ditch had 100 feet; that was the original size. The Settler's Ditch was 75 feet, the Lakeside Ditch was 100 feet. Then there was the Mussel Slough Ditch, the last one taken out, 125 feet per second. The lower Kings River Ditch was of the same size, and in the course of five years or six after we started in we gathered the data of what we had accomplished with the water, the variety of crops we produced, and all that sort of thing, which data is embodied in the State engineer's report. We found that we irrigated 50,000 or 60,000 acres of land when we had a full season, and during our short season 44,000 or 50,000 acres. I can say that we made some mistakes in the construction of our ditches. Our rivers were not hard to approach, and we succeeded in cutting our ditches; but we did not make our distributing ditches large enough. We found when we came to apply the water that we wanted larger sized ditches. We found that the main canals should be the same size from beginning to end, because

if there is plenty of water in the river and you want to bring in a large head of water into your ditch, you have the benefit of the whole ditch.

The CHAIRMAN. You say you got 60,000 acres under cultivation within five years.

Mr. URTON. Yes.

The CHAIRMAN. How much land have you under cultivation now?

Mr. URTON. I am not prepared to say. I have not the figures—actual data; but I suppose 75,000 or 80,000 acres.

The CHAIRMAN. From where did you come originally?

Mr. URTON. I am from Kentucky.

The CHAIRMAN. You had never seen any irrigation before you came to California?

Mr. URTON. Never saw an irrigating canal until I came to this country, except perhaps it was on the car coming through.

The CHAIRMAN. There was none here?

Mr. URTON. There were about 3,000 persons in the county when I came.

The CHAIRMAN. They were not irrigating?

Mr. URTON. Very little.

The CHAIRMAN. What was the land worth when you came on to it?

Mr. URTON. It was sage brush land, some places alkali. It was not a soil on which you could grow wheat, for the reason that if there is much alkali and short rain-fall it parches out.

The CHAIRMAN. Did you raise crops on that alkali land?

Mr. URTON. No.

The CHAIRMAN. Had it ever been done?

Mr. URTON. They had sowed some and raised hay, but it had not been a success.

The CHAIRMAN. Since you have irrigated, has it been a success?

Mr. URTON. Yes; we raise as large crops as anywhere in the State.

The CHAIRMAN. What was the land worth before it was irrigated?

Mr. URTON. What grazing land would be worth—$1.50 an acre.

The CHAIRMAN. What is it worth now?

Mr. URTON. From $40 to $125 an acre, according to location.

The CHAIRMAN. How much land would a farmer require to support himself if he should do the work himself?

Mr. URTON. If they do the work themselves some of them require very little. But one man could take care of 5 or 6 acres if he be industrious.

The CHAIRMAN. What would be a fair sized farm in this valley for a home for a family?

Mr. URTON. If the man did not calculate to hire much labor, but calculated to do the work himself, he could get the best results on from 20 to 40 acres. That would make a very good little farm.

The CHAIRMAN. Not to exceed 40 acres?

Mr. URTON. Of course, the more stock he could raise the better it would be. With alfalfa he could have a larger ranch. But if he confined it to fruits and vegetables, 20 to 40 acres would make a home.

There is another thing which I desire to call to your attention, and that is our water supply and its use. We have a wasteful system here. These ditches which we have in Mussel Slough are calculated to irrigate more territory than they are irrigating. That is my conclusion. These are the things which I wish to call to your attention, so that you may have the benefit of our observation and experience.

The CHAIRMAN. Are there any public lands on which reservoirs *could be* built?

Mr. URTON. Do you mean in the mountains?

The CHAIRMAN. Yes.

Mr. URTON. I suppose there are.

The CHAIRMAN. Have you examined the mountains to see whether there are lakes at the heads of these streams?

Mr. URTON. I suppose there are; I have never been over these streams. We depend a great deal on seepage in these ditches. If we had more ditches to apply the water more quickly we would do away with the labor.

The CHAIRMAN. Of what use would Government surveys be to you?

Mr. URTON. The State has made a good many surveys, and we have a good many statistics compiled.

The CHAIRMAN. You have gotten along pretty well in that direction.

Mr. URTON. Yes. So far as the reservoirs are concerned, I do not know what the last reports are. I do not know whether they have given that a thorough examination or not, but I suppose they have, moderately.

The CHAIRMAN. The reservoir sites are now reserved so that nobody can take them. That has been done by Congress. If those sites are on public lands they may be of use to you.

Mr. URTON. Yes.

STATEMENT OF T. J. McQUIDDY, OF HANFORD, TULARE COUNTY.

The CHAIRMAN. Were you one of the colony that came across the plains and undertook this enterprise at Hanford?

Mr. MCQUIDDY. I am one of that colony. I came through from the State of Tennessee to Mussel Slough. I brought five families with me.

The CHAIRMAN. I asked for information about Hanford because I think it is an illustration of what may be done in a great many places over which we have traveled. Do not make your statement a lengthy one, but give your experience at Hanford.

Mr. MCQUIDDY. In the year 1873, as many of you who are familiar with the history of the United States know, we had something of a financial panic. The result of that panic was that I found myself in California hunting a home for myself and others. I, by accident more than otherwise, drove my stakes down in Mussel Slough. Contrary, however, to the judgment of a few friends whom I had in Tulare County, acquaintances who had preceded me to this country, my judgment was that the soil was here. Arriving here in the month of October I found that the heat was here, and consequently came to the conclusion that but one thing was lacking, and that was moisture. I then went to the Kaweah River and found it flowing and unappropriated. The question then was, could we make the application of the water to the land. In my own judgment I thought we could, and, getting a civil engineer, demonstrated it by running a line of levels from Kings River.

Then the question was, how about getting that water out? There were two small ditches lower down on the Kings River, which were being operated to some extent and irrigating a small area of land. The result of that irrigation was satisfactory to me, it being the first I had ever seen.

Early in 1874 I left with my family and, as I stated, four other families, and made what was then known as and called the Tennessee settlement in Mussel Slough. In a few days we organized what was known

as the Settlers' Ditch Company. I think eighteen or twenty of us joined in that organization. I think there were two men in the company who had means enough to lay in six months' provisions. The remaining sixteen members of the company did not have anything. We realized that there was an undertaking ahead of us. It was a big undertaking to take out the water and irrigate the land. But, as Mr. Urton stated, we were there and could not get away. So we went to work and succeeded in getting the water from the Kaweah, from what is known as the Cross Creek Tunnel. We built the Settler's Ditch in two years. We succeeded in irrigating an area of land there covering our homes, with the happy results of big yields.

It is not necessary to go into detail and tell you how we did it; but we did it. We had yields of wheat and barley running from 20 to 60 bushels to the acre. We had fine melons, large squashes, and an abundance of everything that we wanted that would grow on the land. Of course, our fruits did not come on; our orchards were planted since. But you see what can be done by irrigation. [Pointing to an exhibit of fruit and vegetables in front of the committee.]

The CHAIRMAN. Is a portion of that fruit from Hanford?

Mr. MCQUIDDY. A portion of it from Hanford and vicinity, and a portion is from Visalia and the neighborhood of Tulare—all the result of irrigation. That is the history in brief.

The CHAIRMAN. Did you have any accumulated capital to aid you in any way until after you got your land irrigated? Did anybody come in to assist you with capital, or did you do it yourselves?

Mr. MCQUIDDY. That will draw out a statement. After one year's work on the ditch we found ourselves without means. We went out in harvest time and accumulated enough to buy a few sacks of flour, and went to work again. The ditch was not completed, and the question was, what could be done to go on with the work. We could not live without water, and we could not prosecute the work without some means. It was suggested that if we would incorporate a company and make it responsible for any debts that might be contracted, we could find some one who could loan us money. We said, we have done so much; we have demonstrated to every thinking man that we can accomplish everything that we have started out to do, and if we issue scrip and pay ourselves off in that scrip for our work we can find men to furnish us supplies. We did that, and it worked handsomely. The scrip was issued to us, we pledged it as security to Mr. Jacobs, of Visalia, and others, and we raised money and provisions that enabled us to complete our ditches. The ditches being completed, we went to work and cultivated our lands, raised crops, harvested them, paid our debts, and we are now a happy people.

The CHAIRMAN. How long was the ditch that you constructed?

Mr. MCQUIDDY. It was 14 miles when first constructed, and it is some 18 miles now. About the same time Settler's Ditch was built Lakeside Ditch was built, which went through the same ordeal, except a little more capital was invested. The People's Ditch was gotten through at the same time and upon the same plan, and the Lower King's River Ditch was constructed in the same way.

The CHAIRMAN. Then, with these three ditches, you irrigate 75,000 acres of land.

Mr. MCQUIDDY. Yes. It was said by some people that we lived on bean and crow until we got those ditches constructed. The land in Mussel Slough is worth from $25 to $125 per acre.

The CHAIRMAN. What was it worth when you began?

Mr. MCQUIDDY. I would have to say that Mr. Sullivand, an old stockholder in the company, stated on oath that he would not pay 25 cents an acre for it. It was a dry, sandy plain. But it was rich land—some of it too strongly impregnated with alkali.

STATEMENT OF TIPTON LINDSAY, OF VISALIA, TULARE COUNTY.

The CHAIRMAN. Give us any information that you may have on the subject of irrigation of arid lands and the use of water, and state what use, if any, Government surveys would be to you, if you have considered the matter.

Mr. LINDSAY. I will very briefly and more particularly speak in reference to the United States land district. For thirty years I have been a resident of this district. It is situated between the third and eighth standard, ranges 13 and 38 east from Mount Diablo, and embraces three hundred Government townships. According to our State engineer, one hundred and twenty-five of those townships are susceptible of irrigation, and about twenty-five do not require irrigation to produce ordinary agricultural crops. Hence, about one-half, not quite 7,000,000 acres, is agricultural land of the best quality.

As I stated, I have resided here thirty years, and my occupation has been so varied that I have visited on horseback almost every township in the valley, and have visited all the regions in the mountain country where horsemen can go, and I have assisted to some extent in making the canals which now irrigate a portion of this district.

Irrigation commenced here in 1871. Prior to that time only a few gardens had been irrigated by stock-raisers. Since 1871 we have irrigated within this land district, which embraces more than half of Fresno, all of Tulare and half of Kern Counties, twenty-two townships. The White River, the Tule, Deer Creek, and Kings River afford ample water to irrigate our one hundred and twenty-five townships, which our engineer tells us are susceptible of irrigation. We have Mount Whitney, which is the highest mountain in the United States, and we have the largest trees discovered on the continent.

The CHAIRMAN. State the size of your trees.

Mr. LINDSAY. The General Grant is 41 feet in diameter, and all the other trees are almost of that size.

The CHAIRMAN. What is the highest? Has it been measured?

Mr. LINDSAY. Not to my certain knowledge. I measured it as well as I could when I visited there, and I call it something over 300 feet. A little part of the trunk is broken away. In this land district the mountains are so situated that on the north side in shady spots we have perpetual snow. In this valley where you are now, and you are about in the center of the United States land district, the gardens bloom every month in the year, and while we are misrepresented in reference to climate, I say to you, Senators and Representatives, that I have lived here and raised a family, have been here for thirty years, and have never missed a meal, and my family has been as healthy as I could wish to see.

Now, we have one hundred townships to irrigate, and the water that we have been using in our wasteful way has been pretty well consumed or buried in the sand. We are at this time only supporting about eight persons to the square mile, while we are capable of supporting eighty, and not supporting them as European paupers but as American citizens. But I promised to be brief.

The people whom I represent do not expect or believe that the Congress of the United States has arrived at that stage of liberality or that intelligence in reference to irrigation that King James did in the twelfth century, when he drove all the Moors out of Spain and found there an irrigation system not dissimilar from ours of to-day. But we do ask you, as Representatives, to report back that we ask to have reserved the lands which the Government now owns on the ridges of our mountains and at the heads of our rivers, that we may have reservoirs to hold a sufficiency of water for purposes of irrigation. We ask that the growth there shall not be burned off annually by foreigners and sheep-herders, leaving our hills bare and thus allowing our waters to be gone in April when they should be there in June.

I have from observation and from information obtained from others familiar with that locality prepared a small plat of the townships, thinking that the land there should be reserved.

The CHAIRMAN. What is your opinion about the propriety of repealing all laws for the sale of timber land and having the Government deal the timber out to those who may require it, under regulations that shall preserve the undergrowth—allowing everybody to have as much timber as they may need for their use? Do you think that would help to stop this destruction of timber?

Mr. LINDSAY. In this land district with which I am entirely familiar it ought to be stopped, and should have been stopped five years ago.

The CHAIRMAN. Have the speculators to any considerable extent in this district purchased the timber?

Mr. LINDSAY. It is difficult to judge whether they are speculators or not. Of course, only one individual can take a quarter section. That is all that has been taken. Still a number of sections have fallen into one company's hands. There is still a part of it owned by our citizens —one-quarter section. That is all that has been taken in the last three years.

The CHAIRMAN. Have you observed what effect the denuding of the hills has had upon the streams?

Mr. LINDSAY. Certainly; in my judgment, in the last decade the water supply has been less late in the season than in preceding years.

The CHAIRMAN. The snow keeps back the moisture until late in the season?

Mr. LINDSAY. Yes; particularly in the mountains where this timber belt was so dense that the snow remained until July. But they have burned it off to get their stock through, especially the sheep, and large forests and bodies of timber have been destroyed.

The CHAIRMAN. If the growth were allowed to remain, would it reproduce quickly?

Mr. LINDSAY. Yes, if let alone.

The CHAIRMAN. Have you paid attention to the duty of water in this section? How much is required to irrigate an acre of land?

Mr. LINDSAY. I can not give you any certain figures on that head. I can only say that 10 inches of rain-fall properly distributed will raise an ordinary agricultural crop.

The CHAIRMAN. You spoke of the water being very wastefully used now.

Mr. LINDSAY. That is owing to strife between the different companies, and the fact that we run the water for miles over beds of sand when it should be in the proper channel.

STATEMENT OF M. E. DE WITT, OF TULARE.

The CHAIRMAN. Make any statement which you may desire to make in regard to irrigation.

Mr. DEWITT. If there is any point upon which you particularly wish information, I wish you would ask questions.

The CHAIRMAN. How long have you resided in Tulare County?

Mr. DEWITT. Twelve years.

The CHAIRMAN. What is your occupation?

Mr. DEWITT. Farmer.

The CHAIRMAN. Have you farmed by irrigation?

Mr. DEWITT. Yes.

The CHAIRMAN. What kind of crops do you raise?

Mr. DEWITT. Principally alfalfa—some fruit and grapes.

The CHAIRMAN. How much alfalfa do you raise to the acre; how much can you get in a year?

Mr. DEWITT. I have cut as high as 8 tons to the acre.

The CHAIRMAN. How much is an average crop when well attended?

Mr. DEWITT. Two or three tons to the acre for a cutting.

The CHAIRMAN. How many cuttings in a year?

Mr. DEWITT. From three to four; that is with plenty of water.

The CHAIRMAN. Then the average crop would be 6 tons to the year?

Mr. DEWITT. Upon the average, yes. It would run from 6 to 8 tons; probably 6 tons would be an average.

The CHAIRMAN. Have you been up in the mountains here, and are you familiar with Mount Whitney?

Mr. DEWITT. No, I am not familiar with Mount Whitney. I am not that far back.

The CHAIRMAN. You have not examined them with the view to finding places for the storage of water?

Mr. DEWITT. No, I have not.

The CHAIRMAN. Is there now plenty of water for all the land in this county?

Mr. DEWITT. Oh, no.

The CHAIRMAN. What proportion of it has water?

Mr. DEWITT. I would say that probably there is, under the present system, water enough for one tenth of it.

The CHAIRMAN. You think it could be very much improved?

Mr. DEWITT. It could be, indeed.

The CHAIRMAN. By storing it and saving it in proper reservoirs?

Mr. DEWITT. Yes; by taking the water all out before it reaches the sand-beds in the valley and putting it into the main canal on each side of the river, even before it leaves the mountains or foot-hills. In that way there could be one-half or two-thirds of the water saved.

The CHAIRMAN. Is there anything further that you wish to say?

Mr. DEWITT. There is one point I would like to say a word about, and that is with regard to the sinking of water into the sand-beds. Here we have a granite and sand formation. On the Tule River some years ago there was an artesian well, and while the water flowed in that river that well flowed an inch and a half over the casing, and when the water receded in the Tule River, it receded in the well—went down 3 or 4 feet below the surface. The first flow was struck at 300 feet.

The CHAIRMAN. I think it is obvious that the water sinks in the gravel. There is gravel up above, and the water sinks in that and gets into the clay strata. When you tap it below you bring it up. That is

an artesian supply, and when the supply is dried up the well will be dry.

Mr. DEWITT. That water will not reach the surface except by tapping the artesian supply. The waste is very great. We only get a small portion of the water. Our ditches come out from the foot-hills almost to the lake, and the system is very crude. But the storage of water and the taking of water out in main canals on each side of the channel would increase the supply sufficiently to irrigate the entire country.

This fruit which you see here, a good portion of it, is raised on land which, when I came to this county twelve years ago, was absolutely desert land. No man could make a living, raise grain or wheat or any other kind of crop. I know that myself, and I was superintendent of the canal when the water was first brought into this section of the country.

STATEMENT OF J. M. MOORE.

Mr. Chairman and gentlemen, I will state that I have been in this country for fourteen years, engaged in farming, with and without irrigation, principally with it, raising wheat; and in that time there has been out of fourteen crops planted without irrigation but seven reaped. Anything that was irrigated, of course, succeeded, and as a rule the crops that are raised even in good years without irrigation will not yield as heavy as those that are irrigated. This year I had a piece of ground, and the water came down in January, before I plowed. I turned some on one evening and in a short time flooded about 20 acres. As soon as I could go on to it I plowed the whole piece. There were 130 acres that I sowed in grain. Where the water was run onto the land the yield was 25 bushels to the acre, and where it did not, the yield was 7; and it was put in at the same time.

The CHAIRMAN. This was winter irrigation?

Mr. MOORE. This was winter irrigation. My experience has been this year as well as other years—and I have been engaged in harvesting and running thrashing machines in this county, and I have been over a great portion of it—that where they had water or the benefit of it they had a crop that paid; but where they did not, the yield was very light, not sufficient to pay expenses. There is no use in taking land in this county to farm without water to depend on, because you can not make a living out of it for ten years, and support a family; and probably the more acres a man has the worse off he will be. But with water and a fair amount of land, 160 acres, he would have no trouble in making a living, and at much less expense.

But in relation to land in alfalfa. I find that wheat impoverishes our land; it becomes poorer with every crop we take off, whether we irrigate it or not. But we can put it in alfalfa, and it will pay a large revenue where they have water, and will pay interest on a valuation of $100 per acre, and it will be better land in ten years than it was before it was put in alfalfa; that is to say, it will produce more grain after it has been in alfalfa for ten years with water, and after it has been plowed up.

The CHAIRMAN. Is there anything in the water which you speak of in producing continuous crops of wheat?

Mr. MOORE. I do not know that there is. I did not notice any particular difference. Of course, water impregnated with alkali would not *be as good* as water in a purer state. That is my experience with it.

I think from my experience in this county that the only hope for the county, and the only way that the people can make a living here, is through a system of irrigation. With that the county is capable of supporting a very large population; but without irrigation the population must be limited, and the land of very little value; because if you take away entirely the influence of water the land will not produce a crop, on an average, every other year.

The CHAIRMAN. Will it produce all-around crops?

Mr. MOORE. No; it will not.

The CHAIRMAN. A farmer can not go on and produce all-around crops and support a family without water?

Mr. MOORE. No; he would only raise small grain; something that he could put in in the winter.

STATEMENT OF A. O. ERWIN, OF TULARE.

The CHAIRMAN. What is your profession?

Mr. ERWIN. I am a farmer.

The CHAIRMAN. Do you farm in this county?

Mr. ERWIN. Yes.

The CHAIRMAN. By what means do you farm?

Mr. ERWIN. By irrigation.

The CHAIRMAN. State anything that you think would be of interest to the committee.

Mr. ERWIN. My experience has been only of recent date, and I do not know that I could add anything to what has been said about the means of procuring water. My knowledge is after the water is upon the land. As to the sources of supply and the amount to be obtained, I do not know anything. I raise alfalfa, stock, and fruits, and as I have said, I have been here but a short time, and our fruit trees are not bearing, so that I would not be able to give any idea of the returns we expect to receive. Alfalfa being a crop realized very soon, I know the value of our land for that purpose. We have hopes in the direction of fruit, because we have seen what has been done by those who came here earlier, and who have trees and vines that are bearing.

The CHAIRMAN. You require irrigation to produce trees and vines?

Mr. ERWIN. Yes.

The CHAIRMAN. Then you have had no experience that would justify you in saying anything further?

Mr. ERWIN. In alfalfa we find a very remunerative crop. We expect usually five to six tons per acre every growing season.

The CHAIRMAN. What do you do with alfalfa?

Mr. ERWIN. Sell it.

The CHAIRMAN. How much per ton do you receive for it?

Mr. ERWIN. From $5.50 to $7.50 per ton at the stack. Aside from the amount we get for our hay we usually get from $12 to $15 per acre for winter pasturage, as alfalfa affords pasturage the entire year. During the winter we take in outside stock and our own stock, and it affords us that much per acre. We have a young vineyard started, and a young orchard started. The trees are growing in a thrifty manner, and this season we harvested the first crop. Of course it is small—it is not a fair showing. There are others who can give you an idea of what it will do. By a proper mode of irrigation we can do well. We can get too much as well as too little water, you know. Our alfalfa we water once a year; our trees and vines of certain kinds of fruit we

water less than that. An orchard well started, well rooted, in a good healthy condition, will do watered once every other year. We water by flooding, by bringing the water onto the land and covering the entire surface, and the ground retains the moisture. A crop we had charge of we raised what would be 80 bushels of Egyptian corn per acre. We cut that. That shows that with a proper amount of irrigation our soil will produce everything in abundance.

STATEMENT OF E. A. BROILER.

The CHAIRMAN. Are you familiar with the mountains? We want a description of the mountains. Tell us how they retain the snows, what there is up in them, and what is necessary to be done to preserve the moisture.

Mr. BROILER. I have been back in the Sierra Nevadas for two seasons on fishing excursions. We went up to the foot of Mount Whitney. We talked with the sheep men who go in there in the summer and get what grass they can. They also burn up dead timber and everything in their way, and, as a matter of course, since the burning down of the timber and the destruction of young trees, young forests, the snow melts off a great deal more rapidly than it did a few years ago, when it was covered with underbrush. That is what they tell me back there.

The CHAIRMAN. Is that true all along the Sierra Nevada Mountains?

Mr. BROILER. It is, so far as I have gone.

The CHAIRMAN. What remedy would you suggest for that?

Mr. BROILER. I believe there should be some way to keep the Government lands from being run over by people who pay nothing for them, by foreigners, not even voters—men who go out there in the summer time with herds of sheep and destroy our forests. There should be something done to stop them. The timber is as far back as Mount Whitney, too far back to bring it out as lumber. It is 60 or 70 miles back there. There are fine chances there for reservoirs. There are two lakes on Kern River, one a mile long and a half mile wide, and it is quite level land around them, with a gulch at the lower end, where a dam 150 or 200 feet would run water back 2 or 3 miles.

The CHAIRMAN. Are there any flats there that discharge through a narrow gorge?

Mr. BROILER. Yes, some small and some large.

The CHAIRMAN. How is it on these other rivers—Kings River and White River?

Mr. BROILER. Kings River is as large a river as the Kern River, but I have had very little experience up on Kings River.

The CHAIRMAN. How is the White River?

Mr. BROILER. I understand there are some flats there; and on Tule River there are some flats. On Kern River there have been some surveys where there are some places for reservoirs—down near the Kaweah.

The CHAIRMAN. That is for this county.

Mr. BROILER. Yes; that is for this county. And I wish to say in connection with the Kaweah River that we do not use a quarter or a fifth of the water that comes out of that river.

The CHAIRMAN. Even during the season that you are irrigating?

Mr. BROILER. Yes. The water that comes out of the mountains goes into a hard flat. Turn down a thousand feet of water at the head of the stream, and before it comes out, drawing 200 or 300 feet of water,

and about two-fifths or three-fourths would be wasted in the flats. We should have some system of irrigation. Water could be brought out of the Kaweah where it comes out of the mountains with a canal on each side of the river on solid firm ground. If that were done, we would have water enough to irrigate this whole county. As it is now, there is not enough. On the headwaters of the Kern there is a scope of country 50 miles wide, as fine as a park. We are anxious that that should be set aside as a Government reservation, and if you will do it, I think the people of this county will build a wagon road up to Mount Whitney and give the people a chance to go there.

The committee adjourned to meet on call of the chairman.

STATEMENT OF SAMUEL FOWLER, OF TULARE.

The CHAIRMAN. The committee will hear your views.

Mr. FOWLER. When we first brought water to irrigate the land around Tulare the old settlers said that we could not bring the water on the dry plains. The water had left the old channels and had made a new channel, known by the name of St. John. We knew if we turned the water back into the old channels where it ran before the flood of 1862 we would have a hard job, for the streams that were filled with sand had grown full of willows, which would have to be grubbed out and then the sand scraped out. The land was very rich on the old channels, and the best of the land could be bought from $4 to $6 per acre. We knew the value of water on the west side in Merced County, which made us undertake the enterprise. We got a little water on the land in 1875. In 1876 the barley grew 4 feet high on land that was made wet in 1875.

The land by the side of that irrigated land, and which only had the benefit of the rains, grew 1 foot high and dried up and made no grain. We knew the land was well adapted for irrigation and that under such a system it would increase in value at least twofold. A few of us kept at work to bring the water into this neighborhood until we succeeded. A new life began for Tulare. Orchards, vineyards, and alfalfa fields were planted. The horses in place of being turned out on the plains to be "locoed"* and become useless were turned into the alfalfa and got fat. Hogs got on the alfalfa, and then we got hogs with short noses and sold the ones that had noses a yard long that had to go to the lake and run them down to the mussel shells to make a living. We began then to see the wilderness blossom as the rose. Men who had money came into the country and bought land. One firm bought 10,000 acres of land and planted it in fruit and vines (raisin grapes). They recently told me that it would take one thousand hands next year to harvest and take care of the fruit, etc. With water we can raise two crops; first a wheat crop, irrigate the land, and when the wheat is harvested plow and plant corn, which will keep the weeds from growing.

That is two crops with one irrigation. We thought we were happy.

Water is the salvation of this region. While we learned the value of the water the men on the old channels learned the same. As we had turned the water in part into the old channel we took the water out by ditches as needed. For the lack of sufficient money to keep out of these old channels we got into trouble. Men living on them below

*A poisonous weed which destroys animals that feed upon it.

where our water was taken out brought suits against us, such as ripra rian claims, etc. What water they did not want to use they permitted to go to the lake, and a great deal of money has been spent in lawsuits and much hard feeling had been engendered, which has stopped the growth of this part of the country. We have made a move to remedy this trouble, and we have organized an irrigation district under the "Wright law." We now feel encouraged by the fact that there are some men in Congress that are taking interest in the men that feed the hungry of the United States.

Adjourned.

BAKERSFIELD, CAL., *August* 31, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF O. BROWN, OF BAKERSFIELD.

The CHAIRMAN. What is your occupation?

Mr. BROWN. A farmer.

The CHAIRMAN. How long have you been farming?

Mr. BROWN. Eight years.

The CHAIRMAN. What crops do you raise?

Mr. BROWN. Alfalfa, corn, and some other things. I also attempted to raise some wheat. What I wish to talk about is with regard to the people who have staid on these arid lands. I have 160 acres. We are obliged to abandon the land for the reason that we have no water. We have perfected our ditches and paid for our land, but we have been obliged to abandon it because of lack of water. We are now living on rented land in Bakersfield.

The CHAIRMAN. Is there any unappropriated water supply that could be gotten?

Mr. BROWN. That is what I wish to talk about. The Kern River here is appropriated to a great extent by a large water monopoly, a water company. That is to say, the natural flow of the Kern River is taken up. But there is a flood flow that I do not think is appropriated by anybody. That is the point which the people on these plains wish the committee to understand. There is water that could be properly stored, enough to irrigate the whole country.

The CHAIRMAN. What do you know of the facilities for storing water? Have you examined to see if there are places that could be used for that purpose?

Mr. BROWN. I have not examined; but I know many persons who have been around the headwaters of the Kern River.

The CHAIRMAN. Where are those places situated? Are they on the public lands?

Mr. BROWN. I do not know, but I believe there are places on public lands where these flood waters could be stored. But what I was going to say is this: the company that has appropriated the natural flow of the river purposes to build a reservoir down at the mouth of the river near Buena Vista Slough. That is a bad idea, and for this reason: When the water is run off millions of gallons would run to waste that could be brought here for irrigation purposes. If the water should be stored in Buena Vista Slough it would only irrigate one man's land, while if

it were stored in the mountains and taken in ditches after it comes on the plains it would irrigate every acre of land within a radius of 40 miles from where it comes out of the mountains to where it gets on the plains.

The CHAIRMAN. Would public surveys determine some of the questions that now perplex you?

Mr. BROWN. It would determine some of these matters. There was a survey made by an engineer of California; and I saw a report of that survey. That report stated that there was sufficient water if it were properly stored.

The CHAIRMAN. Do you regard a survey of these reservoir sites as important?

Mr. BROWN. It is very important. But I wish to say that inasmuch as there are more or less places suitable for reservoirs that have been already taken up, you want to see to it that California passes a condemnation law so that the land on those places can be condemned and taken. I suppose there is a law already in existence that is sufficient for that purpose. But if the Government would make the reservoirs, there is law in California to protect the people who make the ditches.

The CHAIRMAN. We will not discuss what the Government will do; what we wish to understand is whether this land is worth reclaiming. Now, persons crossing the continent look upon this land as a desert.

Mr. BROWN. It is not a desert; it is one of the finest spots in the country.

The CHAIRMAN. What can you raise here?

Mr. BROWN. With irrigation you can raise anything that grows under the sun.

The CHAIRMAN. Can farming be carried on without irrigation?

Mr. BROWN. Nothing can be done without irrigation. Without the water the land is entirely valueless. That is why I say that every drop of water should be stored in the mountains and brought here on the public land. It is probably one of the best places for irrigation in California or in the United States.

The CHAIRMAN. Why so?

Mr. BROWN. Because the land responds to irrigation better than any other place in California. My idea is that no cold country is fit for irrigation; we must have a hot country.

The CHAIRMAN. How much alfalfa can you raise to the acre?

Mr. BROWN. From 7 to 9 or 10 tons per acre per year. That number of tons I have myself raised here.

The CHAIRMAN. How with regard to potatoes?

Mr. BROWN. Of potatoes about 200 sacks per acre.

The CHAIRMAN. How many in a sack?

Mr. BROWN. From 120 to 125 pounds. It is probably not as fine a potato as that grown in some other places.

The CHAIRMAN. How much of barley?

Mr. BROWN. From 50 to 75 bushels per acre.

The CHAIRMAN How with regard to oats?

Mr. BROWN. Oats, not so well; from 40 to 60 bushels per acre.

The CHAIRMAN. How much of wheat?

Mr. BROWN. Wheat will run from 30 to 60 bushels to the acre.

The CHAIRMAN. Is this a good fruit country?

Mr. BROWN. Yes.

The CHAIRMAN. What kind of fruit can you raise here?

Mr. BROWN. Most of the fruits—peaches, apricots, prunes, oranges, lemons, figs, bananas—all kinds of fruits that are raised in any other

country. We have the best peach orchard here that is in the United States, cultivated by irrigation.

Mr. HINTON. What is the value of land without water?

Mr. BROWN. I consider my land worth 10 cents an acre without water; with water from $100 to $500 an acre.

STATEMENT OF J. A. BLODGETT, OF BAKERSFIELD.

The CHAIRMAN. Have you recently visited the headwaters of the Kern River?

Mr. BLODGETT. Yes.

The CHAIRMAN. Describe what you saw on your trip there.

Mr. BLODGETT. In reference to irrigation the main thing was the natural reservoir sites in the mountains and valleys.

The CHAIRMAN. Did you go there for the purpose of investigating those things?

Mr. BLODGETT. No, for pleasure, for my health. But, of course, being interested in land in Kern County, being a farmer and in other enterprises, I took a good deal of interest in the matter, and I particularly noticed the adaptability of these mountains and valleys for reservoirs. The south fork of the Kern River is almost a succession of valleys and basins from the summit of Mount Whitney to the plains. There are, perhaps, from six to eight or ten valleys and natural basins commencing almost from the summit of Mount Whitney. Most of those meadows are nearly level. The river flows on a fall of about 7 feet to the mile.

The CHAIRMAN. Does it discharge through narrow gorges?

Mr. BLODGETT. Yes, through narrow gorges 7 or 8 miles long. There will be a level of 4 or 5 miles, and then another valley, and so on. There are valuable meadows on Whitney Creek, the Bradshaw, the Templeton and Walker Meadows, and the Manache, within the valleys in the south fork.

The CHAIRMAN. Are these meadows private property?

Mr. BLODGETT. Some of them. Some of them were taken up under the swamp-land act. The meadows are where there are springy bodies of land, where water oozes out of the mountains, and where during the winter months the valleys are full of snow. In many places you can not ride across them. They are pasturage lands.

The CHAIRMAN. Has there been no money spent to reclaim them?

Mr. BLODGETT. There does not appear to have been. The impression that a person would get of the land is that it has no value except for pasturage, and in a few months of the year it can not be tilled. They have frosts there, and the crops grown would be few and of no value.

The CHAIRMAN. In your judgment how much water runs to waste there during the year?

Mr. BLODGETT. I have no technical information on the subject. In many seasons, the rainy seasons, there is a large volume of water that runs to waste. I might say off-hand that a third of the flow of the river runs to waste. I am certain, however, that there is an immense quantity of water sufficient to fill reservoirs in a short time.

The CHAIRMAN. You say you are a farmer?

Mr. BLODGETT. Yes, and interested in other kinds of business as well.

The CHAIRMAN. What crops do you raise?

Mr. BLODGETT. Alfalfa.

The CHAIRMAN. How much alfalfa can you produce to the acre? What do you consider a good crop of alfalfa?

Mr. BLODGETT. From 6 to 9 tons.

The CHAIRMAN. Have they in this country gone extensively into the fruit business?

Mr. BLODGETT. Not extensively. But few persons have gone into it extensively.

The CHAIRMAN. With what success have they met?

Mr. BLODGETT. They have been very successful. They have raised a quality and quantity unsurpassed anywhere.

The CHAIRMAN. Do you raise good oranges here?

Mr. BLODGETT. Very few. There have been few experiments in that line. In the bottoms they can grow them successfully, as experiments have shown. Of course, the orange belt as a rule is above the irrigation belt; it is thermal; there has been no water with which to irrigate.

The CHAIRMAN. Take land here that is not under water, or upon which it is not possible to get water, and state what it is worth.

Mr. BLODGETT. Two dollars and a half per acre, for grazing purposes.

The CHAIRMAN. Will it sell for that?

Mr. BLODGETT. It will not sell for more than that.

The CHAIRMAN. Would it bring that price?

Mr. BLODGETT. It would bring about that for sheep pasturage.

The CHAIRMAN. Can you farm here without irrigation?

Mr. BLODGETT. No, not in this country.

The CHAIRMAN. You can not raise regular crops without irrigation?

Mr. BLODGETT. No.

The CHAIRMAN. If you raised crops without irrigation it would be an accident?

Mr. BLODGETT. Purely.

STATEMENT OF W. CANFIELD, OF KERN COUNTY.

The CHAIRMAN. In what part of Kern county do you reside?

Mr. CANFIELD. About 13 miles southwest from Bakersfield.

The CHAIRMAN. Are you farming there?

Mr. CANFIELD. Yes.

The CHAIRMAN. From where do you get your water?

Mr. CANFIELD. From the Kern River.

The CHAIRMAN. Are you on the east or west side of the river?

Mr. CANFIELD. About 6 miles south of the river.

The CHAIRMAN. How long have you been farming there?

Mr. CANFIELD. Since 1873.

The CHAIRMAN. What crops have you been raising?

Mr. CANFIELD. We have not been raising any line of crops but cattle and horses; occasionally a crop of corn in the latter part of the season. Alfalfa has been the principal crop we have raised.

The CHAIRMAN. How much alfalfa can you raise to the acre?

Mr. CANFIELD. From 5 to 7 tons to the acre.

The CHAIRMAN. Have you some fields in alfalfa?

Mr. CANFIELD. Our business is mostly pasturing instead of growing hay.

The CHAIRMAN. Without a water right what is good alfalfa land worth?

Mr. CANFIELD. I presume a fair price would be $2.50 an acre.

The CHAIRMAN. With a water right what would it be worth?

Mr. CANFIELD. With a water right probably $50 an acre. I speak of the water right as something very definite. For instance, land situated near the source of supply would be worth a good deal more than if it were at the end of the canal. That is according to my experience.

The CHAIRMAN. Is there anything further that you wish to state about farming here?

Mr. CANFIELD. I wish to state that I believe in this committee and in the value of these surveys. So far as the facts are concerned I am satisfied that when measures shall have been taken for a just and equitable distribution of the water it will be a blessing to this country. But I believe more depends upon an economical use of the water after it is on the land than anything else.

The CHAIRMAN. State how much water you require to irrigate.

Mr. CANFIELD. That is a difficult question for me to answer. It depends almost entirely upon the nature of the soil.

STATEMENTS AND INCLOSURES OF WILLIAM B. CARR, OF BAKERSFIELD AND SAN FRANCISCO.

GENTLEMEN: Relative to your investigation of the subject of the selection and reservation of Government lands for reservoir sites in our mountain ranges, to serve for storage of the surplus waters of the streams having their sources in the vicinity of such sites, and relative to the subject of irrigation in general, which necessarily is inseparably united with its oftentimes necessary forerunner, and at all times able coadjutor—storage—I have been invited to give to your committee the result of my experience for the past fifteen years in the cultivation of arid lands by irrigation.

As a means of introducing the various topics of plans of irrigation, practice of irrigation, and results of irrigation, I submit herewith inclosures as follows:

Inclosure No. 1.—Map of a portion of Kern County, Cal., showing lands in which J. B. Haggin and his associates are interested, between Kern River and the north line of the county, and also main canals and distributing ditches, demonstrating system of irrigation there in operation, and also explanation of the same.

Inclosure No. 2.—August 29, 1889. Plan showing system of irrigation in Kern County, Cal., and bird's-eye view of one system of irrigation as operated in Kern County, Cal., and explanations thereof.

Inclosure No. 3.—Clipping from the Resources of California (a monthly newspaper published in San Francisco, Cal., October 1888), descriptive of the water supply and irrigating system of Kern County, Cal., embracing description of its canals, amount of water owned by each, length and manner of handling the water, and explanatory of beneficial results derived therefrom.

Inclosure No. 4.—August 26, 1889. Estimations of cost to ditch and check lands in Kern County, Cal., by W. L. Dixon, engineer, referring to sections 9, 16, 21, and 22, township 28 south, range 26 east, Mount Diablo base and meridian.

Inclosure No. 5.—August 14, 1889. Letter from W. L. Dixon, giving estimation of cost to ditch and check sections 15 and 23, township 28 *south*, range 26 east, Kern County, Cal.

Inclosure No. 6.—August 24, 1889. Statement of lands ditched and checked season of 1887 and 1888 on District No. 4, Kern County, Cal., showing total cost and average cost per acre of this work.

Inclosure No. 7.—August 24, 1889. Statement of lands ditched and checked season of 1888 and 1889, on Buena Vista Ranch, showing total cost and average cost per acre of this work, Kern County, Cal.

Inclosure No. 8.—August 26, 1889. Statement of lands ditched and checked season of 1888 and 1889 on District No. 4, Kern County, Cal., showing total cost and average cost per acre of this work.

Inclosure No. 9.—October 29, 1889. Description of irrigation as conducted in Kern County, Cal.

Inclosure No. 10.—October 28, 1889. Memorandum of lands seeded to corn and alfalfa, Poso District, season of 1888 and 1889 (as per R. P. O. 1246), together with a few remarks on the irrigation works of Kern County, and the change which has been effected through them in a formerly arid and worthless country.

Inclosure No. 11.—October 30, 1889. Map showing location of haystacks at Poso, Kern County, Cal., 1889, with explanation relative thereto.

Inclosure No. 12.—October 28, 1889. Memorandum of hay cut season of 1889 on Kern County property, with particular explanations as connected with the hay production in the Poso District, on lands seeded during the previous winter and spring, supplemented by remarks on irrigation.

Inclosure No. 13.—List of photographs taken in Kern County, Cal., sent to Maj. John W. Powell, United States Geological Survey, Washington, D. C.

Inclosure No. 14.—August 26, 1889. Memorandum relative to products raised at various times in Kern County, Cal., with remarks upon same.

Inclosure No. 15.—R. P. 1271, August 7, 1889. Copy of newspaper notice, showing comparisons between years 1867 and 1888 relative to number of voters, population, and assessed value of property.

Before referring further to these inclosures let me say that I have given fifteen years close study to the subject of irrigation in all its branches and details. I and my associates have at all times employed able and skillful civil engineers, the best obtainable for the purpose. The results which we have accomplished and the systems of irrigation which we now commend have been developed by large expenditures in experimenting, numerous mistakes, and indefatigable energy. When our irrigation works in Kern County were first commenced, the subject was comparatively new in the United States. Upon our first entrance into this project we had no idea that our irrigation operations would attain their present gigantic proportions. Most of the practical farmers of California considered the project a foolish one, which would never yield a return upon the investment.

To-day there is not another district in California possessing irrigation works as extensive and as efficient as those of Kern County; there is not a property in California having a larger body of cultivated land than has our property in Kern County. There are properties of larger areas, perhaps, but none other with as much land which has been broken with the plow.

Without irrigation Kern Valley would still be as it was fifteen years ago, and as its unirrigated portions are to-day, wholly unfit for anything save the precarious pasturing of a very limited number of stock, which, in any season save *of most favorable* conditions, would starve to death

on lands now heavy with their burden of life-sustaining irrigated vegetation.

The absolute necessity for irrigation in Kern County has been proven by experiments repeated during the last fifteen years, made oftentimes on a scale of a thousand or more acres, by those who, at the time, thought irrigation unnecessary, unless, possibly, to procure a showing of green in the spring of a favorable year, in order to effect a sale of land to one unacquainted with Kern County. No one at all acquainted with its physical conditions would any more attempt to raise a crop without irrigation than without seed.

Of the great interior valley of the southern portion of California, known as the San Joaquin Valley, the southern extremity or pocket is known as Kern Valley, for which latter the waters of Kern River are the principal source of water supply. The waters of this river have been diverted through canals, and have reclaimed thousands upon thousands of acres of land, and now the question arises as to the further utility of those waters for the reclamation of arid lands, whether owned by the Government or by individuals, and which I hold can not be accomplished, to any great extent, without reservoir storage. The projects now entertained by your committee have been in my mind, as a provision for the future, for many years. Such a scheme is entirely feasible and practicable in Kern County, and its benefits can not be measured.

Shall the Government's domain be given, rent free, to the wandering, marauding sheep-herder, who, paying no taxes, serves but to consume the scant feed on an immense territory, set fire to Government and private forests with his camp-fires, aggravating the lack of rain-fall, and come in competition with the stock-raiser who spends his money in the reclamation of worthless domain, the increasing of taxable property? Shall the Government's possessions, such as those in Kern County, Cal., that were offered for sale at $1.25 per acre, in the Buchanan administration, without finding a purchaser, be practically withheld from the farmer, who, on account of his limited means, is unable to construct the necessary irrigation works? Or will the Government, by assistance to its people in respect to storage reservoirs, and by enactment of liberal laws for the sale and reclamation of these arid lands, allow the settlers to cooperate in the construction of the necessary irrigation works, resulting in general benefit to the Government, to the State, and to the people?

Irrigation is made necessary from the fact of an insufficiency of rain, and in a district where irrigation is practically possible on a scale of any magnitude, the supplying stream most generally, if not always, has its source in the snow deposit of some mountain range. It is true that, occasionally, a flood of water is supplied to the river from a possibly unusually heavy rain-fall, but the occurrence of such contributions are so erratic as to be unworthy of dependence. Ninety-nine per cent. of the flow of such rivers generally comes, not by rain-fall, but from the melting of almost perpetual snow in lofty mountains; so that, whilst the necessity for irrigation arises from the climatic conditions of the valleys, the water supply of such rivers is almost exclusively dependent upon the climatic conditions existing at the river sources. It is well known to all that the climate of the higher altitudes is similar to that of the frigid zones. The annual seasons are long and cold winters and short summers. As the hot rays of the summer's sun will melt the snow more readily than the mild days of spring or autumn, it follows that the down-pour of the irrigating river occurs in midsummer, with a *smaller* flowage in spring and fall, and to a great degree a cessation in

winter. These conditions are general in their character, and Kern County is included in their embrace.

Whereas Kern River often affords ample water in March and September, the season of plentiful supply is more often restricted to the months from April to August, both inclusive, with the large floods occurring in the months of April, May, June, and July, and the most limited supply of the year prevailing generally from October to February, both inclusive. It is during this period of comparative drought, beginning with the month of November and extending through February and possibly March, that the farmer needs moist earth through which to plow, needs moisture to sprout his planted seed, and being sprouted, the irrigator needs moisture to keep it alive until the down-coming of the melted snow allows him to irrigate; and in the early spring his pasture land, if it could be irrigated, would soon be green, whereas otherwise it is unproductive until the down-coming of the river.

It can be readily imagined that where irrigation is practiced and is a necessity these varying conditions of the water supply must control and limit the amount of land which can be successfully cultivated. The cultivation of land by irrigation being a purely artificial method, depends for its highest success upon its absolute independence of natural causes. In these arid countries, while the occasional and uncertain rain-fall is of advantage to the farmer, it can not and must not be relied upon; and it may be stated here that lands in these arid regions can not be cultivated by irrigation utilized only during the flood months of the year. It is therefore evident that the limited water supply of spring, autumn, and winter restricts the area possible to be irrigated to a point far below that which the summer's flood would wet, at the same time being inadequate possibly to guaranty the farmer against the loss of his most profitable crop, that sown in the winter.

At the same time it is easily apparent that it is quite impossible to in any way utilize the immense floods of water, for which in the midsummer the entire canal capacity of any irrigating district can not possibly provide, and which, with but a small portion of its volume, serves to wash and break the canals, leaving its greater volume to flow to waste. This waste either goes finally to the sea or sinks into the desert sands, or if spread out into lakes in the valleys is lower in level than the major portions of those valleys, and thus inaccessible for irrigation, and in the generality of such latter cases evaporates with almost incredible rapidity under the burning sun.

If the water which annually goes to waste, as I have described, could be utilized for irrigation, it would multiply, many times, the area which can be irrigated by the amount of water now capable of being utilized. If, taking from the more than abundant flowage of summer, and adding to the insufficiency of spring, autumn, and winter, all of the water which is formed by the melting of the snows in the mountains could be so utilized that the farmers would not be dependent for success upon any natural and uncertain supply, the great problem of the settlement and development of those portions of the country, which ninety-nine men out of every one hundred now deem uninhabitable, would be solved. I think that your committee, in the progress of its investigations, must have become satisfied that I am right in this, and I have no doubt that I am in accord with the committee in believing that this can be accomplished in no other way than by the construction of artificial reservoirs, and the utilization of natural reservoirs, in the Rocky Mountains and in the Sierra Nevadas.

The question now under investigation by your committee, the storage of surplus waters, must be formulated into a shape for permanency and operation. There has been, for many years, no question raised for discussion in Congress, which, properly and intelligently handled, can be productive of greater good to the nation at large than can this subject of irrigation. One of the chief sources of our nation's wealth and thrift is its agricultural capabilities, and any grand expanding of those capabilities can but be a most powerful factor in the Union's history.

In my three topics of Plans of Irrigation, Practice of Irrigation, and Results of Irrigation, as mentioned in the fore part of this statement, I take pleasure in referring you to the inclosures herein made, as enumerated in the commencement:

PLANS OF IRRIGATION.

Inclosure No. 2, as more fully explained in inclosure No. 9, shows the system of irrigation which has been most generally adopted in Kern County, together with explanations regarding the same.

Inclosure No. 3, clipping from the "Resources of California," descriptive of water supply and irrigation system of Kern County, Cal., is very accurate data, with the exception of what is stated relative to the flow of Kern River, which is in excess of the actual amount obtainable from that source. This inclosure, from its accuracy in other respects, will give you a very comprehensive idea as to the irrigating systems there in operation, and as to the capabilities of the same.

Inclosure No. 1, taken in connection with inclosure No. 3, as demonstrating the extent of the irrigation works in one district of Kern County, will convey a conception of what works are required for successful irrigation.

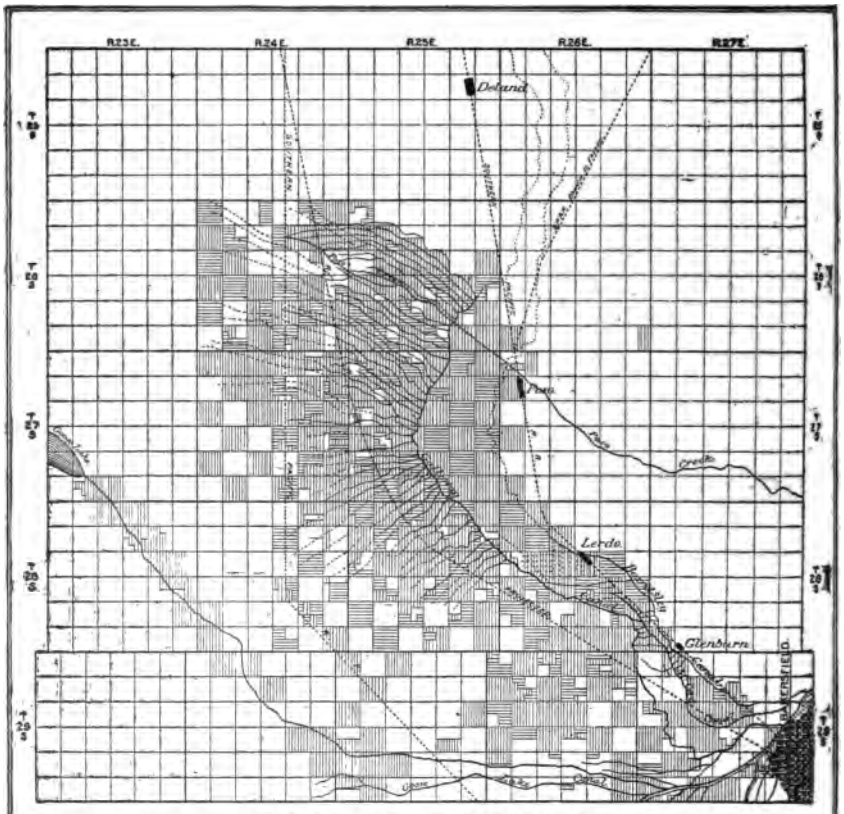
Inclosures Nos. 4 and 5 are furnished to show the estimated cost, as furnished by one of our engineers as indicative of the cost of reclamation works, on lands which we now have in contemplation of irrigation; and inclosures 6, 7, and 8 show similar authenticated figures on lands already ditched and checked, the average cost of this work ranging, as you will note, from $9.78 to $14.37 an acre, the lower average costs, as shown in inclosure No. 6, representing the cost of work done in 1888 on land on which a portion of the constructions were made prior to 1888. The final average cost of $10.95 an acre, as shown on page 4 of inclosure No. 8, is about the cost for which this work can be done, varied somewhat by the topography of the land to be reclaimed.

PRACTICE OF IRRIGATION.

Inclosure No. 10, showing again the cost of these irrigation works and the application of the same to the cost of our crops, as well as the practicability and efficiency of such works, indicates the present history of our work, while Inclosure No. 11, showing the volume of products of irrigation, and Inclosure No. 12, showing what returns we are obtaining from our expenditures in this direction, tell the daily repeated history of irrigation, as we have proven and are proving its profitable and satisfactory results.

RESULTS OF IRRIGATION.

The photographs, taken in Kern County, Cal., sent to Maj. John *W. Powell*, of the U. S. Geological Survey, Washington, D. C., and as



MAP OF A PORTION OF KERN CO. CALA.
SHOWING LANDS IN WHICH J.B. HIGGIN AND HIS ASSOCIATES ARE INTERESTED
BETWEEN KERN RIVER AND THE NORTH LINE OF THE COUNTY AND ALSO MAIN
CANALS AND DISTRIBUTING DITCHES DEMONSTRATING SYSTEM OF IRRIGATION IN
OPERATION OCTOBER 1889

enumerated in Inclosure No. 13, indicate more clearly than words can tell the story what results have arisen from irrigation in the lower portion of the San Joaquin Valley The barren, arid lands, lacking irrigation and devoid of vegetation, are shown; the water is seen running its way through the many ditches to perform its labors, and the irrigated fields are shown heavy with their growth from unity of sun, soil, and water; the thousand occupations arising from irrigation are made to appear as in the life; and after examining these photographs, if any one doubts the results of irrigation in a country valueless without it, he will have to come to Kern County, examine the reality, and abide by the result of his observations.

Inclosure No. 14, enumerating the various products which we have been able to raise through irrigation, and Inclosure No. 15, showing a comparison of taxable property, population, etc., in Kern County, as between 1867, prior to irrigation, and 1888, during its progress, also serve to show the results therefrom.

And now, in conclusion, gentlemen, let me say that what I have stated here in reference to the advantages and necessities of irrigation, the storage of surplus waters, and the construction of reservoirs, applies equally not only to Kern County but to the whole of California, and also to all of the now arid country lying tributary to the rivers having their sources in the Sierra Nevada and Rocky Mountains. The climatic conditions are the same, both in the valleys where irrigation is necessary and in the mountains where the sources of the water supply lie.

I can not in too forcible terms laud the object that your committee has in view. The most telling results as regards the future of the nation's agriculture can but ensue. I believe that Congress can not be too liberal in the appropriation of money to be used in ascertaining and selecting the best sites for such reservoirs or other storage works, and for the construction of the same. It is certain that whatever is expended will be returned to the Government a hundred fold, and to the nation a thousand fold.

The results of irrigation in Kern County, as here explained, are not by any means the only examples apparent in southern California, and I await with pleasurable anxiety the reports to your committee of the similar experiences of Tulare County, Merced County, Fresno County, San Diego and Los Angeles Counties, and other irrigating districts of California, which can but multiply the brightness of my predictions.

The results thus anticipated can not be accomplished in a year, or a decade, but will demand careful, continuous, and intelligent application, and a mighty Government's helping hand. Therefore, with congratulations to your committee and ourselves on the prospect of a long continuance of your labors so auspiciously begun, let me join my voice to the common sentiment of California that our records, experiences, and results are at your command, and that our best wishes and support attend your labors.

MEMORANDUM CONCERNING MAP OF A PORTION OF KERN COUNTY.

[Inclosure No. 1.]

This map shows that portion of the property in Kern County, Cal., lying to the north of Kern River and to the west of the Southern Pacific Railroad, which J. B. Haggin and his associates have already reclaimed, and are now in process of reclaiming, from an arid, unproductive state, by means of irrigation.

The shaded lines indicate the lands owned by the parties directly interested in this

work of reclamation and irrigation, and who also own the net-work of ditches through which such results have been and are to be effected.

An idea of the magnitude of these operations can be obtained from this map, keeping in view that the length already constructed of the Calloway Canal amounts to 32 miles, and that an extension is in contemplation of 11 additional miles to be of the same size as the present canal, namely 80 feet wide on the bottom and 120 feet wide from bank to bank.

The Beardsley and McCord Canals also supply water to this same district of country, and it is proposed to extend the former 22 miles and the latter 27 miles, as shown by the dotted extensions of the heavy lines indicating the canals, thus largely increasing the extent of the irrigable lands, increasing the area suitable for cultivation and homes, and multiplying the output and taxable property of Kern county.

The interests of these associates are not alone represented by the lands portrayed on this map. They possess an equal amount of property on the south of Kern River, and on all of this vast estate the science of irrigation has been studied in all its branches for over fifteen years, resulting in the Kern Valley of to-day.

On the west bank of the Calloway Canal is constructed, at an altitude, a roadway which serves as an observation point, commanding miles of the sloping plains.

Upon it, with the waters of the canal dancing in the summer sun, one can look far to the westward over fields of waving alfalfa, whose verdant green is a most beautiful carpet with its 3 feet of thickness to the moistened earth. A thousand cattle are in the radius of the eye's circle; a dozen hay stacks oppose their thousand tons of bulk to shut off the view from further fields of green; everything speaks of thrift, of success, of life.

Looking to the eastward above the canal, and on the arid lands not yet reclaimed, one can at once realize the absolute necessity of irrigation, and the results derivable therefrom. In the spring one would see perhaps a patch of short-lived wild flowers, some scant alfilleoria, and perchance some at that time passable grain which some experimenter had planted above the line of irrigation, and which had been sprouted by the light rain-fall. But in the summer the flowers would be withered, the alfilleoria dead, and but a patch of rusty blackened straw, with drooping hollow heads, would tell of the failure of the grain, resulting from want of irrigation. Everything dry and barren, with possibly a few stunted sage-brush, populated only by a passing jack-rabbit, by lizards, and horned toads, would tell the story of Kern County fifteen years ago, and when brought into comparison with the irrigated plenty, would make one conclude that water is king, and that Kern County needs such beneficent kingly rule.

MEMORANDUM CONCERNING PLAN SHOWING SYSTEM OF IRRIGATION, AND BIRD'S-EYE VIEW OF ONE SYSTEM OF IRRIGATING AS OPERATED IN KERN COUNTY.

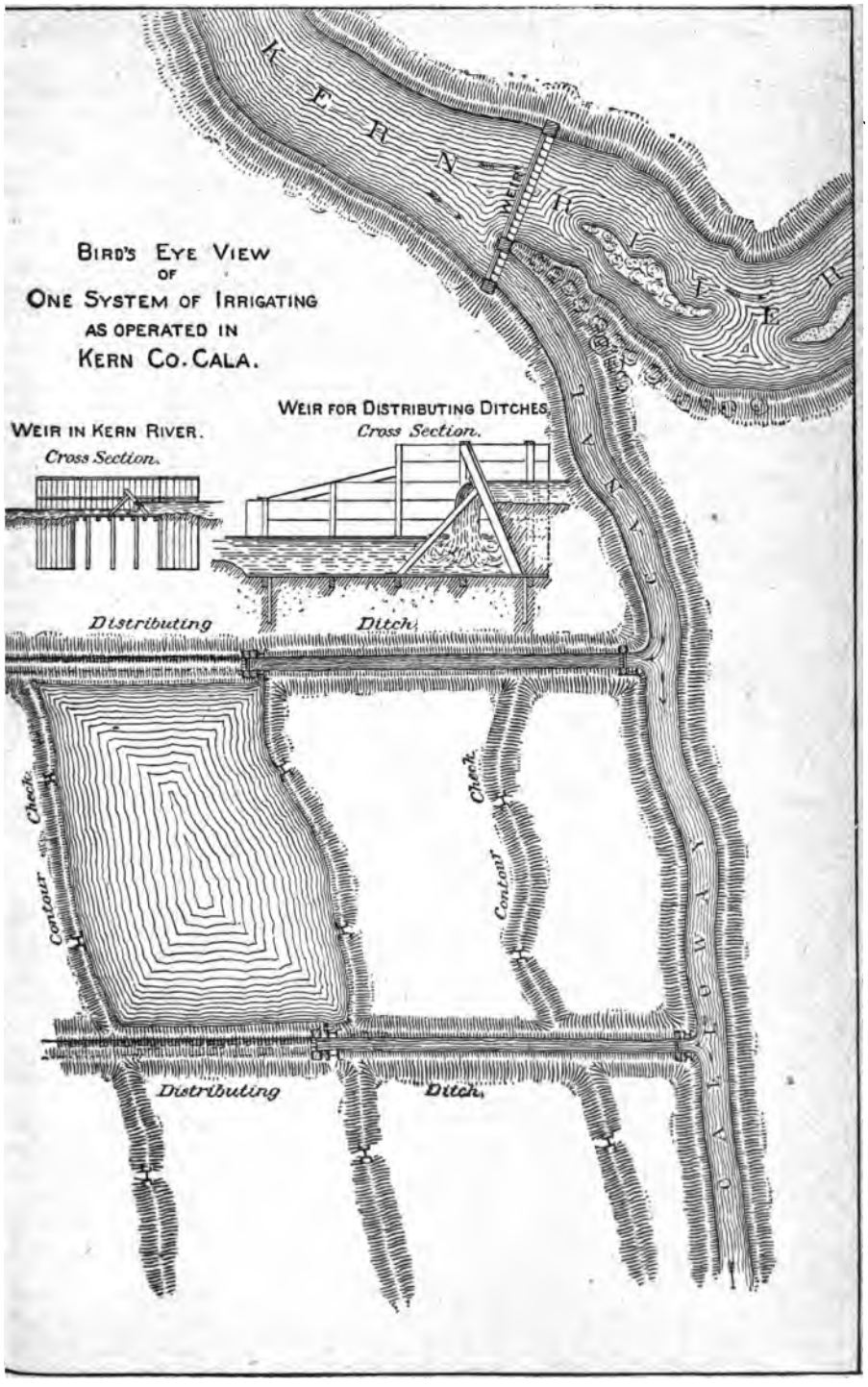
[Inclosure No. 2.]

In the "bird's-eye view" are shown the river, a portion of the Calloway Canal, two distributing ditches, and several contour checks. As indicated by the arrows, the water in the river, arrested by the weir, enters the Calloway Canal through its head-gate and from thence passes into the distributing ditches. In the latter are shown the "drops," acting similarly to the river weir, and forcing the water out of the distributing ditches through the "side gates" of those ditches onto the land inclosed by the contour checks, thus accomplishing the actual irrigation.

In the "plan of irrigation" are similarly shown a portion of the Calloway Canal, distributing ditches, and checks, together with cross-sections of the Calloway distributing ditch and of land in process of irrigation.

The checks are run on a level, and thus at regular intervals of 6, 9, 12, 18, or 24 inches, as desired, act as dams to back the water over the space intervening between the check so constituting the dam and the next check above, as appearing in the cross-section. When the irrigation in one check is completed the surplus water from that check is drained into the next check below, the balance of the water required being supplied from the distributing ditch.

Such is the system of irrigation most general in Kern County, and from its cheapness of construction as compared with other systems and their results, its extreme cheapness of operation, its most satisfactory *results* in the even and thorough distribution of the water, resulting *in thorough* irrigation and profitable returns, it commends itself for


KERN
BIRD'S EYE VIEW
OF
ONE SYSTEM OF IRRIGATING
AS OPERATED IN
KERN CO. CALA.
WEIR IN KERN RIVER.
Cross Section.
WEIR FOR DISTRIBUTING DITCHES.
Cross Section.
Distributing
Ditch
Check
Contour
Check
Contour
Distributing
Ditch

simultaneous irrigation of large areas most strongly as worthy of a foremost place in irrigation systems.

For a more complete explanation of the same subject, see Inclosure No. 9, constituting "description of irrigation as conducted in Kern County, Cal."

DESCRIPTION AND STATISTICS OF THE KERN COUNTY CANAL SYSTEM.

[Inclosure No. 3.]

It is an indisputable fact, and no one need attempt to deny it, that the San Joaquin Valley is a "dry country," especially the southern portion of it. The rain-fall from Goshen to Caliente, a distance of 100 miles, is very light. Kern Valley lies in this district. The annual rain-fall at Bakersfield has been as low as 4 inches. There would be small hope for successful agricultural and horticultural pursuits were there no artificial means of obtaining water.

Kern Valley is fortunately located within a magnificent artesian belt; its limits as yet undefined, but it is of great extent. From the northern border of the county, especially on and south of the southern border of Tulare Lake, it extends through the entire alluvial section of Kern Valley. This artesian district covers the entire country for 15 to 20 miles east and north of Tulare Lake, in Tulare County. But here we have only to do with the artesian district of Kern Valley as far as developed. It covers a distance of nearly or quite 50 miles north and south, with a width of 10 to 15 miles. A fair flow is obtained at a depth of 200 feet, and other flows are obtained at short intervals in going down farther, so that any reasonable quantity of water can be obtained by going deep enough. One of these wells will usually irrigate a section of land; and if the water is collected and stored in reservoirs, some will supply water for 3,000 to 4,000 acres.

In many instances the flow is too great for the farmer, and he has to cap his well to prevent a superabundance of water. Just south of Tulare Lake, in the northern part of Kern Valley, there are more than three dozen of these wells within a radius of 10 miles. Here is the flow of a dozen of these wells in gallons every twenty-four hours, all yielding over 1,000,000 each:

Gallons.	Gallons.	Gallons.
2,500,000	2,200,000	1,600,000
2,500,000	2,200,000	1,500,000
2,400,000	2,000,000	1,500,000
2,400,000	1,600,000	1,200,000

The water discharging from artesian wells, of which there are several on Kern Island, within a distance of about 6 miles from the lakes, maintains a uniform temperature of 71° Fah. summer and winter. This uniform high temperature renders artesian water valuable for winter irrigation. These wells just north of the little lakes of Kern Valley are from 250 to 460 feet deep.

Nature has also placed within reach a water supply for Kern Valley much more ample and economical. The annual local rain-fall is light, yet in the summit of the Sierra, from 35 to 40 miles distant from the eastern border of the valley, it is about 100 inches, from the great fall of snow and precipitation of rain. The altitude of this lofty mountain range is nearly or quite 2,000 feet greater in Kern, Tulare, and Fresno Counties than in the central and northern counties. Here, in this range, rising to an average altitude of 8,000 to 10,000 feet, with Mount Whitney the highest mountain in the United States 15,056 feet, and many other peaks but little less, an immense amount of snow is stored in winter, which does not melt till late in spring and early summer. Fortunately Kern Valley lies right at the base of this immense water-shed of the Sierra.

Kern River is the third largest in the San Joaquin Valley, only exceeded in size by the San Joaquin and King's Rivers in this order. It has two branches in the upper Sierra. The northern branch, which is the longer, with its numerous tributaries, rises right at the base of Mount Whitney, and is fed by the snows of that lofty peak. Its source is in the northeastern part of Tulare County, and it flows 60 or 65 miles in that county in a southwesterly direction, past several lofty peaks, and receives the western drainage of the backbone of the Sierra. After reaching Kern County and flowing 25 or 30 miles below the line the southern branch unites with it, and from there to the plains of Kern Valley the course is southwest. From the source of the North Fork of the river to the mouth of the cañon the distance is 115 miles, in which it falls 10,000 to 12,000 feet in a series of cascades through wild, rocky cañons, alternating with short, level reaches in park-like valleys. From the point where it leaves the mountains proper it flows for 18 miles between high, gravelly banks, then in entering the plains it meanders a little north and south of west 14 miles, where the Southern Pacific Railroad

crosses it about 1 mile north of Bakersfield. Continuing southwesterly a few miles, its course is westerly, after which it takes a northwesterly direction through Goose Lake to Tulare. This is known as New River. Formerly its course from near Bakersfield was nearly south to Kern Lake, then westerly to Buena Vista Lake, then following the slough in a northwesterly direction to Tulare Lake. This is known in Kern Valley as the Old River. Kern, Buena Vista, and Goose Lakes were formed by the overflow of the river. The delta south and southwest of Bakersfield between Old and New Rivers is known as Kern Island.

This river drains a water-shed or catchment area of 2,382 square miles. Caliente Creek and other small streams, which are really tributary to the Kern, Tehachapi, San Emigdio, and Tejon, with other water-sheds, make a total catchment area or water-shed for Kern Valley of 3,445 square miles.

The average discharge of Kern River is 2,700 cubic feet per second. The maximum discharge during the rainy season, and during the melting of the mountain snow, is 19,041 cubic feet per second. There are eight months of the maximum flow or high water from December to July, inclusive. The actual discharge of Kern River the last of May, 1883, by calculations made, was found to be equal to a depth of 1½ inches per month from the whole area or catchment of 3,445 square miles. This gives a depth of 3 inches per month for irrigation over 1,200 square miles, or 768,000 acres, which affords a grand scope and promise of magnificent results to the efforts of a vast population in the valley. The discharge is doubtless much larger from the middle of February to April, when water is most needed for irrigation.

By close calculation it is found that 1 cubic foot per second will irrigate 160 acres. So that from the waters of Kern River alone, properly stored and utilized, can be irrigated all the lands of Kern Valley.

No portion of our country of equal extent can be irrigated at a less expense than Kern Valley, and the soil is of the best and most easily worked character. Right here in Kern Valley, and mainly on Kern Island, we find more than thirty canals, some of them with branches, and all with distributing ditches and several with many, the main canals aggregating some 300 miles in length and covering nearly 475,000 acres, which can be irrigated. About 150,000 acres are now irrigated, producing as fine crops as ever grew. On these irrigated lands, with good care, alfalfa gives four and five crops a year, yielding at least 2 tons to the acre each crop, making an annual yield of 8 to 10 tons to the acre besides affording some pasture. As a rule it is cut every six weeks for eight months in the year. Several years ago, when this irrigating system was first inaugurated, it cost 50 cents per acre to irrigate land. Science and art, with much study and labor, have so far perfected this system of irrigation that now the cost varies from 2 to 10 cents per acre, as a rule, averaging from 2 cents or 3 cents to 5 cents under favorable conditions.

The canal of the Kern River Water and Irrigating Company, known as the Beardsley Canal, the highest on the river, being the most northeasterly of this great system, is taken from the northerly bank in the southeast quarter of section 3, T. 29 S., R. 28 E. It is 8 miles in length, 15 feet wide on the bottom, and 2½ feet deep. It has 10 miles of distributing ditches. It appropriates 47,030 miner's inches under a 4-inch pressure, equivalent to 938 cubic feet per second. This location was made December 2, 1873.

The McCord Canal is taken from the northerly bank of the river in the northeast quarter of section 18, T. 29 S., R. 28 E. The main canal is 4½ miles long, with three branches, having a total length of 10 miles and 15 miles of distributing ditches. The main canal is 20 feet wide on the bottom and 2 and 3 feet deep. This, with the Beardsley, is the means of supply for that portion of the district above the Calloway Canal. It appropriates 5,000 inches, equivalent to 100 cubic feet per second. This location was made March 20, 1875.

The Calloway Canal belongs to the Kern River Land and Canal Company, and is the largest and most important in the system. It comes out of the northerly bank of the river a short distance above the Southern Pacific Railroad Company's bridge, in the southeast quarter, section 13, T. 29 S., R. 27 E. It is 32 miles long, 80 feet wide on the bottom, and 120 on the surface, with banks 7 feet high and 10 to 16 feet wide on top, with inside slope of 4 to 1, and outside 2 to 1. On the west bank there is a delightful driveway the full length. It has a depth of about 6 feet. The grade is eight-tenths of a foot per mile. In 30 miles it crosses Poso Creek by means of a weir 150 feet in length, built in the bed of the creek, and connecting at either end with the lower bank of the canal. This arrangement admits of the use of the winter waters of Poso Creek by diverting them into the canal. It has some 65 distributing ditches, from 8 to 20 feet wide on the bottom, averaging 16 feet, and from 1 to 9 miles long, the aggregate length being about 150 miles. These branches have banks 3½ feet high, intended for 3 feet of water, with slopes 3 to 1, and a grade of $1\frac{6}{10}$ feet per mile, giving to each a capacity of $196\frac{8}{10}$ cubic feet per second. The importance of *this canal* is seen when we state that it covers about 200,000 acres of land. The *head-gate at* the point of diversion from the river is 100 feet long, built of redwood

lumber, 6 by 6 struts, 4 by 6 side posts, and 2-inch flooring. The foundation is 20 feet wide up and down the stream, and has three rows of sheet piling, 4 by 8 Oregon pine, driven to a depth of from 12 to 16 feet, with intermediate or anchor piles of the same dimensions and material to which the sills, 4 by 8, redwood are spiked. There are 25 bays, and the gate-boards are 2 by 6 redwood. The top of the gate is 8 feet from the floor. The gate extends from the right bank out into the stream, and is connected with the weir by an artificial abutment. The weir extends from this abutment southerly across the river, and is 400 feet long, being of similar construction to the head-gate, the only difference being that the gate-boards are twice as long, reaching across the bays. By means of the gate-boards, which are movable, the water is under complete control, and can be regulated at will. The Calloway appropriates 74,000 inches of water, equivalent to 1,476 cubic feet per second. The location was made May 4, 1875.

The McCaffrey Ditch, sharing the head-gate of the Calloway Canal, is 3 miles long, 7 to 8 feet wide on the bottom and is 2½ feet deep. It irrigates the land between the Calloway and the river. The appropriation is 1,296 inches, equivalent to 26 cubic feet per second. The date of location is October 31, 1874.

The head-gate of the Emery Ditch is in the northeast quarter of section 22, T. 29 S., R. 27 E. It is 3 miles long, 6 to 8 feet wide on the bottom, and 2 feet deep. It appropriates 2,000 inches, equivalent to 40 cubic feet per second. Located December 2, 1876.

The Jones and Tuckey Ditch begins in the northeast quarter of section 32, T. 29 S., R. 27 E. It is 4 miles in length, 10 feet wide on the bottom, and 2 feet deep. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second. Located June 24, 1876.

The Railroad Canal, commencing near the corner of southwest quarter of section 31, T. 29 S., R. 27 E., is 3,000 feet long. It is 40 feet wide on the bottom, and 2 feet deep. It empties into Goose Lake slough. It appropriates 31,075 inches, equivalent to 620 cubic feet per second. Its location dates July 24, 1874.

The head-gate of the Wible Canal is in the northwest quarter of section 6, T. 30 S., R. 27 E., and running about 1,000 feet, it discharges into Goose Lake canal, and by means of this canal and Goose Lake slough, its waters are conveyed to the lands to be irrigated. It is 40 feet wide on the bottom, and 2 feet deep. Its appropriation is 5,040 inches, and its capacity 300 cubic feet per second. Located May 1, 1875.

The property of the Goose Lake Canal Company is taken from the northerly bank of Kern River, in the northeast quarter of section 1, T. 30 S., R. 26 E., and runs thence northwesterly 4½ miles, emptying into Goose Lake slough. Flowing through this slough the water is taken out at different points along the slough in ditches. It is 140 feet wide on the bottom and 3 feet deep. It appropriates 90,000 inches, equivalent to 1,795 cubic feet per second. It was located July 13, 1875. The Railroad, Wible, and Goose Lake Canals all empty into the Goose Lake slough, and use it as a common channel to carry their waters to the adjoining lands as far down as Goose Lake, a distance of 22 miles.

The Pioneer Canal, owned by the Pioneer Canal Company, has its head-gate in the northeast quarter of section 1, T. 30 S., R. 26 E. It has a length westerly of 11½ miles, being 60 feet wide on the bottom and 3 feet deep. This canal flows through the entire length of the McClung ranch, which is wholly irrigated by it, and its principal distributing branch, the Pottinger Ditch, 16 feet wide. It also passes through the Buena Vista ranch, furnishing mainly its irrigating waters. Its appropriation is 20,074 inches, equivalent to 401 cubic feet per second. This canal was located April 26, 1873.

The head-gate of the Edwards Ditch is in the northwest quarter of section 1, T. 30 S., R. 26 E. It is 2 miles long, 10 to 12 feet wide on the bottom, and 1 foot deep. It appropriates 1,440 inches, equivalent to 20 cubic feet per second, and was located December 21, 1874.

The James and Dixon Canal is owned by the James and Dixon Canal Company. It commences in the southeast quarter of section 3, T. 30 S., R. 26 E., and runs in a westerly direction about 12 miles. It is 30 feet wide on the bottom and 3 feet deep. Its appropriation is 14,000 inches, equivalent to 279 cubic feet per second. Its location dates April 19, 1873.

The Johnson Ditch is owned by the Lower New Kern River Irrigating Company, and begins in the southeast quarter of section 3, T. 30 S., R. 26 E., a few feet below the James and Dixon Canal, with which its waters join in a shallow slough, a few hundred feet below. Its course is southwesterly about 4 miles. It is 30 feet wide on the bottom and 3 feet deep. It appropriates 8,640 inches, equivalent to 172 cubic feet per second. It was located June 12, 1873.

The Ash Ditch is near the Johnson, and is taken from the river in southeast quarter of section 3, T. 30 S., R. 26 E., and is 1 mile in length, 3 feet wide on the bottom, and 2 feet deep. It has a discharging capacity of 24 cubic feet per second.

The May Ditch leaves a short arm of the river in the northwest corner of the south-

west quarter of section 18, T. 30 S., R. 26 E. It is 2 miles long, 8 feet wide on the bottom, and 2 feet deep. Its appropriation is 4,000 inches, equivalent to 80 cubic feet per second. Its location was made November 29, 1873.

The Joice Canal is taken from the river in the northeast corner of the southwest quarter of section 23, T. 30 S., R. 25 E. It is nearly 4 miles long, 12 feet on the bottom, and 2 feet deep. It appropriates 6,250 inches of water, equivalent to 129 cubic feet per second. Its location was made May 26, 1873.

The Dixon Canal is a branch of the Joice Canal, diverting the water from the latter for about 2½ miles, and then it branches out to the northward, irrigating lands on the borders of the reclaimed swamp-land district. It is 8 feet wide on the bottom and 4 feet deep. The appropriation is 3,456 inches, equivalent to 69 cubic feet per second. Its location dates April 13, 1875.

The foregoing canals and ditches are all on the north side of the New Kern River, or now Kern River proper. Those on the south side, about the same number, are located on both sides of Old River. The first one in order on the river, locating at the highest point on the left bank of the stream, is the property of the Kern Island Irrigating Canal Company, called the Kern Island Canal.

It is taken from Kern River near the southeast corner of the southwest quarter of section 9, T. 29 S., R. 28 E., about 2½ miles northeast of Bakersfield, through which town it passes. It is 18 miles long, with a width at the head-gate of 48½ feet on the bottom and a depth of 4 feet. It terminates at Kern Lake. At Bakersfield the canal makes a vertical fall of nearly 20 feet, furnishing water power for a large flouring mill. This important canal has two main branches, the town branch, supplying Bakersfield and vicinity, having a length of 2 miles, and a central branch, diverging from the canal south of the town, and running nearly parallel to it, varying from one-half to 2 miles distant, for a distance of 10 miles in a southerly direction. This branch has a width of 20 feet on the bottom, and a depth of 3 feet, with slopes of 3 to 1. The central branch is one of the best irrigating canals in the valley. It has nineteen drops in the distance of 10 miles, placed at intervals of half a mile. The Kern Island and its branches have thirty-one lateral ditches, besides a connecting ditch with the Stine Canal, having a total length of over 80 miles. The Kern Island Canal appropriates 20,000 inches, equivalent to 400 cubic feet per second. Its location dates from the latter part of 1870.

Next below the Kern Island is the Old South Fork Canal. It is taken from the river in the central northern part of the northeast quarter of section 17, T. 29 S., R. 28 E., about three-fourths of a mile below the head-gate of the Kern Island canal. It runs 3 miles southwesterly into the bed of the Old South Fork of Kern River, in which its waters are conveyed to Kern Lake in a nearly southerly direction. The canal has a width of 26 feet on the bottom, and is from 2 to 3 feet deep. Its distributing ditches aggregate 7 miles, one of the principal of which is the Cotton Ranch Ditch, irrigating 1,100 acres of alluvial bottom lands, north of and adjoining Bakersfield. Most of the water diverted into the Old South Fork is turned into the Panama Slough, and again diverted below by the Panama Ditch. This canal is also used at times as a feeder for the Kern Island Canal. The appropriation is 3,800 inches, equivalent to 75 cubic feet per second.

The Farmers' Canal, owned by the Farmers' Canal Company, takes its water from the river in the northeast quarter of section 24, T. 29 S., R. 27 E., about 200 feet above the Southern Pacific Railroad bridge across Kern River with a 48 feet opening, fronting parallel with the river, the water entering the canal at right angles with the stream. The first artificial channel to the Panama Slough is about three-quarters of a mile in length. The total length of the main channel is about 15 miles, consisting wholly of natural sloughs. It has four miles of branch constructions, varying from 10 to 20 feet in width. It has 30 miles of distributing ditches. The artificial channel is 50 feet wide on the bottom and 3 feet deep, and the natural channel varies from 20 to 50 feet in width, with a depth of 6 to 10 feet, having nearly vertical banks. The soil through which it passes is generally a firm, clayey loam, and permits natural irrigation of adjacent lands by percolation. A great deal of this land along the old channel is thus kept constantly moist and requires no irrigation. It appropriates 14,400 inches, equivalent to 287 feet per second. Its location was made April 29, 1873.

The Castro Ditch derives its water at the junction of Old and Kern Rivers, in the northeast quarter of section 26, T. 29 S., R. 27 E. It is 16 feet wide on the bottom, 2 feet deep, and 5 miles long. It crosses Panama Slough, and irrigates a small amount of land east of that channel. The appropriation is 1,000 inches, equivalent to 20 cubic feet per second.

The Stine Canal, belonging to the Stine Canal Company, has its head-gate also at the junction of Old and Kern Rivers, adjoining that of Castro, in the northeast quarter of section 26, T. 29 S., R. 27 E. It occupies the bed of Old River for the distance of half a mile. This canal is 80 feet wide on the bottom, 3 feet deep, and 15 miles long. It has two main branches, with numerous forks, varying in width from *12 to 20 feet* on the bottom, and having an aggregate length of 32½ miles, and 41½

miles of distributing ditches. It is next in importance, in this system, to the Kern Island Canal, and shares with the Farmers' Canal in irrigating T. 30 and 31 S., R. 27 E., besides supplying water for other lands west and south. Its appropriation is 55,980 inches, equivalent to 1,117 cubic feet per second. It was located December 12, 1872.

The Anderson Canal heads also in the northeast quarter of section 26, T. 29 S., R. 27 E., at the junction of Old and Kern Rivers. Its head-gate connects with those of the Stine and Castro, and the same system of wing-dams serves for all. The canal runs southwesterly 4 miles, is 15 feet wide on the bottom, and 2½ feet deep. This canal is used exclusively for irrigating Stockdale ranch, located about 5½ miles southwest of Bakersfield. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. The location was made October 9, 1872.

The Gates Canal, owned by the Gates Canal Company, is taken out of Kern River, in the southwest quarter of section 26, T. 29 S., R. 27 E., and runs in a southwesterly direction 2½ miles. It is 12 feet wide on the bottom and 2½ feet deep. It also is used exclusively in irrigating Stockdale ranch. Its appropriation is 5,057 inches, equivalent to 101 cubic feet per second. This canal was located originally without record early in 1872, and relocated October 7, 1878.

The Buena Vista Canal belongs to the Buena Vista Canal Company. Its head-gate is in the northeast quarter of section 33, T. 29 S., R. 27 E., and runs southwesterly through Bellevue ranch, located about 8 miles west of Bakersfield. It is 13¾ miles long, 30 feet wide on the bottom, and 3 feet deep. It has numerous ditches of various dimensions. Its appropriatioa is 14,000 inches, equivalent to 279 cubic feet per second. Its location was July 15, 1870.

The James Canal, which is the property of the James Canal Company, heads in the northeast quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly 17½ miles, is 60 feet wide on the bottom the first 3 miles and 40 feet the remaining distance, and is 3 feet deep. This canal also flows through Bellevue ranch, supplying water for this ranch and all lands still further south and west. The amount of appropriation is 19,730 inches, equivalent to 394 cubic feet per second. Date of location October 15, 1871.

The Plunkett Canal, belonging to the Plunkett Canal Company, commences in the northwest quarter of section 33, T. 29 S., R. 27 E. It runs southwesterly through Bellevue ranch, and is used exclusively for it. Amount of appropriation is 5,057 inches, equivalent to 101 cubic feet per second. Date of location, December 31, 1872. It is 3¼ miles long, 12 feet wide on the bottom, and 2½ feet deep.

The Meacham Canal is the property of the Meacham Canal Company, commencing in the northwest quarter of section 6, T. 30 S., R. 27 E., and flows through Bellevue ranch southwesterly about 4 miles. It is 12 feet wide on the bottom and 3 feet deep. Its appropriation of water is 1,500 inches, equivalent to 30 cubic feet per second. It was located April 15, 1873.

The Wilson Canal commences at a point on Kern River, near the head-gate of the Meacham Canal, in the northwest quarter of section 6, T. 30S., R. 27 E., and also flows through Bellevue ranch 2½ miles in a southwesterly direction, and is 5 feet wide on the bottom and 2 feet deep. It appropriates 500 inches, equivalent to 10 cubic feet per second, and was located August 15, 1874.

The Henley Canal begins in the southeast quarter of section 9, T. 30 S., R. 26 E., and runs southwesterly 2½ miles. It is 3 feet wide on the bottom and 2 feet deep. The amount of the appropriation is 2,880 inches, equivalent to 57 cubic feet per second. Its location dates January 29, 1874.

The Frazer Canal takes its waters out of Kern River, in the northeast quarter of section 16, T. 39 S., R. 26 E. It flows southwesterly 2½ miles, and is 5 feet wide on the bottom, with a depth of 1½ feet. It appropriates 2,600 inches, equivalent to 52 cubic feet per second. It was located April 15, 1873.

The Kern Valley Water Company has two main canals for the reclamation of swamp land in district No. 21, in Buena Vista slough, and a distributing canal. The principal canal is that on the west side of the district, following, generally, the border of the swamp lands for a distance of 24 miles. At its head it is 125 feet wide on the bottom, 7 feet deep, with sides sloping from 3 to 1 and from 7 to 1, and a grade of nine-tenths of a foot per mile. The grade is very irregular, and we give it in detail. For one-half mile the grade is nine-tenths of a foot; 9 miles, it is 2 feet; one-half mile, $2\frac{6}{10}$ feet; and 1¼ miles, level; vertical drop, $1\frac{6}{10}$ feet; 1 mile, 8 feet; 2 miles, level.

Below this main channel, a parallel distributing canal, 30 feet wide on the bottom and 2 feet deep, was constructed about 10 miles long. On the east side of the swamp a canal about 6 miles long was constructed for irrigation purposes, having a width on the bottom of 25 feet, a depth of 3 to 5 feet, and side slopes of 3 to 1. The appropriation of water of the Kern Valley Water Company is 100,000 inches, equivalent to 1,995 cubic feet per second, and its location dates April 7, 1877. The appropriation of the Kern Valley, east side, is 30,000 inches, equivalent to 599 cubic feet per second, and the location dates April 9, 1877.

Résumé of the canal system of Kern Valley.

Name of canal.	Length.	Appropriation.	
	Miles.	*Miner's inch.*	*Cubic feet.*
Beardsley	8	47,230	938
McCord	14⅝	5,000	100
Calloway	32	74,000	1,476
McCaffry	3	1,296	26
Emery	3	2,000	40
Jones Tuckey	4	1,000	20
Railroad	⅜	31,075	620
Wible	⅛	5,040	100
Goose Lake	4⅜	90,000	1,795
Pioneer	11½	20,074	400
Edwards	2	1,440	29
James and Dixon	3	14,000	279
Johnson	4	8,640	172
Ashe	1	1,200	24
May	2	4,000	80
Joice	4	6,250	125
Dixon	2½	3,456	69
Total	99⅛	315,701	6,293
Kern Island	30	20,000	400
Old South Fork	3	3,800	75
Farmers	19½	14,400	287
Castro	5	1,300	26
Stine	47½	55,980	1,117
Anderson	4	5,057	101
Gates	2½	5,057	101
Buena Vista	13½	14,000	279
James	17½	19,730	394
Plunket	3½	5,057	101
Meacham	4	1,500	30
Wilson	2½	500	10
Henley	2½	2,880	57
Traver	2½	2,600	52
Kern Valley Water Company	40	130,000	2,594
Total	197½	281,561	5,618
Grand total	297⅛	597,262	11,911

The first division of the above table represents the canals on the northern bank of Kern River. The second division those taken out of the southern bank of the Kern.

GENERAL REMARKS.

The first and most important consideration, in a section where agricultural success is wholly dependent upon irrigation, as in Kern Valley, is that of the amount and permanence of the water supply, for upon these depend the prosperity of the community. Fortunately Kern River, which is virtually the sole source of supply for all this valley, is a stream of large volume, whose waters can be entirely diverted without injury to any public interest and whose discharge, though variable, is unfailing.

The river heads, as we have shown, among the loftiest peaks of the Sierra Nevada, whose ice-fields and beds of snow only yield to the heat of midsummer, furnishes an immense volume of water long after the winter rains of the foot-hills and valley are lost sight of. The rains of winter and the melting snows of summer on the upper Sierra thus maintain a full flow in Kern River for about two-thirds of the year, the period covering the greatest demand for irrigation. Kern River has a slope through the valley of 6 to 8 feet per mile, and lies in a shallow, sandy bed, with banks of sandy soil 3 to 6 feet high. These are favorable conditions, and enable water to be taken out at almost any point at comparatively small cost. Few permanent, costly dams, or very expensive head-works have been found necessary; a simple wing-dam of sand and brush, running out into the channel of the river at an acute angle up the stream, serves every purpose, in most cases, for diverting water into the canals, there being only five weir extensions across the river in the whole system.

Then, again, the slope of the irrigable lands of the valley is so great there is no difficulty in running canals in almost any direction over them, nor in distributing water in the smaller ditches, or in draining it off. It is therefore peculiarly favorable for irrigation, yet the soil is too friable to permit of canals of any considerable *size taking* the natural slope of the ground without serious erosion and damage.

WORKS IN THESE CANALS.

The grade over these sloping plains is regulated by "drops," or weirs, placed at proper intervals, with movable weir-boards, which are also convenient and necessary for raising water to enter distributing ditches. These drops are constructed similarly to the canal head-works, and are characterized by an absence of ponderous gates for regulating the water and extreme lightness of timber used, studying the greatest economy in material. Head-gates are a necessity when the water is taken out of the river to control the admission of water to the canal. They are made entirely of wood, there being no stone readily accessible in this vicinity. The better class of these head-gates are constructed upon a foundation of anchor-piles driven into the sand as far as possible, with sheet-piling of 2-inch planks at the upper and lower sides of the structure.

Weirs, as before indicated, are constructed not only for drops, but for raising water for entering distributing ditches. Side gates are at the head of distributing ditches for the purpose of admitting water from the canal into such ditches. They are constructed upon the same principle as head-gates.

The canal flume is the usually constructed flume for carrying one stream of water over another across a gulch or ravine.

Wing-dams are built of brush and in the river, from the lower side of the mouth of the canal up the stream, at an acute angle with the current, to turn the waters of the river into the canal.

Waste-gates are built at the heads of canals and also along their course to let off any oversupply of water. Inverted siphons are put into canals for the purpose of carrying their waters under another canal.

A module is put into a gate or other structure for the measurement of water.

EFFECT ON SOILS IN KERN COUNTY.

It has been positively demonstrated that upon all the sandy soils, at least, which form the principal area of land in this valley under cultivation, the effect of years of irrigation has been a marked increase in their fertility and an apparent change for the better in their composition. The mountains drained by Kern River are composed of friable granite, which is very rapidly disintegrating. Great quantities of this, as well as vast quantities of gypsum from the gypsum beds over which this river flows, are transported by the river to the plains below. Water and cultivation disintegrate the coarser particles, and these fertilizing elements become dissolved and prepared for plant-growth. In filtering through this porous soil all this sediment and fertilizing matter contained in the water is detained and a perpetual restoration is furnished. Some of the richest fields in Kern Island, producing large annual crops and of some productions two crops, were barren wastes of sand before being fertilized and reclaimed by irrigation.

IRRIGATION IMPROVES CLIMATE.

The change for the better in the climate of Kern Valley since the general introduction of irrigation has been as marked as the improvement in the soil. This is more noticeable, in fact, because it affects the physical condition of every one. While it is admitted that formerly there was a good deal of malaria in Kern Valley, we now say with positiveness that there is scarcely any at all. The healthfulness of Kern Valley will compare favorably with any others in our sanatory State. Malarious fevers were quite prevalent in the valley formerly, but have been almost wholly abated mainly, it is claimed, by these measures.

Old sloughs containing stagnant water have been purified by the introduction of pure mountain water running through them. Jungles of miasma-breeding willows have been cleared, swamps drained and dried out, and decaying vegetation on every hand destroyed. Besides, it may as well be understood first as last, that the miasmatic influences prevailing here in the early settlement of Kern Valley were largely owing to the people drinking surface water. Since artesian and deep-well water is used a radical sanitary change is seen.

OTHER RESULTS OF IRRIGATION.

Prior to fourteen or fifteen years ago there were not in this valley more than a dozen families outside of Bakersfield and vicinity, and almost all the entire valley was a barren, desolate, sandy waste or desert, except the immediate environs of Bakersfield. Now about 150,000 acres of this land is made to "blossom as the rose," yielding as fine crops as grow, and capable of sustaining a population of 100,000 people, while not more than one-fourth of the irrigable lands of the valley are under direct cultivation.

ESTIMATIONS OF COST TO DITCH AND CHECK LANDS, MADE BY W. L. DIXON, ENGINEER.

[Inclosure No. 4.]

Section 9, T. 28 S., R. 26 E., 260 acres, below Beardsley:		
Building 1¼ miles 12-foot ditch, at $387.10		$483.87
Putting in ten 12-foot gates, including material		777.00
		1,260.87
Ditching	per acre..	6.30
Checking	do....	3.75
		10.05
Section 16, T. 28 S., R. 26 E., 640 acres:		
Building 4 miles 12-foot ditch, at $387.10		1,548.40
Putting in thirty 12-foot gates, including material		2,331.00
		3,879.40
Ditching	per acre..	6.06
Checking	do....	3.75
		9.81
Section 21, T. 28 S., R. 26 E., 420 acres:		
Building 2.6 miles 12-foot ditch, at $387.10		1,006.46
Putting in twenty gates, including material		1,554.00
		2,560.46
Ditching	per acre..	6.09
Checking	do....	3.75
		9.84
Section 22, T. 28 S., R. 26 E., 622 acres:		
Building 3.87 miles 12-foot ditch		1,498.07
Putting in twenty-nine 12-foot gates, including material		2,253.30
		3,751.37
Ditching	per acre..	6.03
Checking	do....	3.75
		9.78

LETTER FROM W. L. DIXON, ENGINEER.

[Inclosure No. 5.]

BAKERSFIELD, *August* 14, 1889.

DEAR SIR: I herewith submit a report of the cost of the work of ditching and checking section 23, T. 28 S., R. 26 E.:

Ditches, section 23, T. 28 S., R. 26 E.:		
Earth-work on 5 miles of ditches		$1,935.53
Labor on gates	606.04	
Lumber and nails	948.39	
		1,554.43
Cost per mile, including gates $697.99		3,489.96
Checking 640 acres on section 23, T. 28 S., R. 26 E		2,395.72
Cost per acre, $3.04 to check.		5,885.68
Total cost per acre to ditch and check, $9.20.		
Total cost per acre to ditch, $5.46.		
Section 15, T. 28 S., R. 26 E.:		
Ditching 4.35 miles, at $387.10 per mile for earth-work		1,683.88
Thirty-one sets of 12 inch gates, at $77.70 each		2,408.70
Cost per acre to ditch, $6.60; cost per acre to check, $3.74, 620 acres		2,318.80
Total cost per acre to ditch and check, $10.34.		6,411.38

Statement of lands ditched and checked, season of 1887 *and* 1888, *on District No.* 4, *Kern County, Cal., in townships south, ranges east, Mount Diablo base and meridian (the different lands being described in left-hand margin of sections, townships, and ranges, the figures appearing in this order):*

[Inclosure No. 6.]

Location.	Ditched and checked prior to 1888.	Ditched and checked in 1888.	Total ditched and checked.	Cost of ditches and checks built in 1888.	Rate per acre of total cost of ditches and checks built in 1888.
	Acres.	*Acres.*	*Acres.*		
Sec. 29, T. 26, S., R. 25, E. Sec. 20, T. 26, S., R. 25, E. Sec. 21, T. 26, S., R. 25, E.	500	800	1,300	$3,901.20	$4.88
Sec. 9, T. 26, S., R. 25, E. Sec. 16, T. 26, S., R. 25, E. Sec. 15, T. 26, S., R. 25, E. Sec. 22, T. 26, S., R. 25, E.	340	1,260	1,600	7,445.10	5.90
Sec. 17, T. 26, S., R. 25, E.	500	.....	500	.....	.....
Sec. 23, T. 26, S., R. 25, E.	.....	640	640	4,388.90	6.86
Sec. 5, T. 26, S., R. 25, E.	(*)	250	250	2,076.58	.....
Sec. 5, T. 27, S., R. 25, E.	(†)	200	200	1,660.00	8.30
Sec. 6, T. 27, S., R. 25, E.	300	180	480	3,698.03	.....
Sec. 7, T. 27, S., R. 25, E.	.....	40	40	533.47	19.23
Sec. 33, T. 26, S., R. 25, E.	.....	212	212	789.38	3.72
Total	1,640	3,582	5,222	24,492.75	.....

* Alfalfa.

† Egyptian corn.

Statement of lands ditched and checked, season of 1888 *and* 1889, *on Buena Vista Ranch, Kern County, Cal., T.* 30 *S., R.* 25 *E., Mount Diablo base and meridian.*

[Inclosure No. 7.]

Sections.	Rate per acre of total cost.	Ditched and checked.	Cost of ditching.	Cost of checking.	Cost of gates.	Proportion of surveys.	Total cost of ditches and checks
		Acres.					
4	.....	283	$399.20	$754.44	$195.06	$84.54	$1,433.24
3	$5.53	38	236.26	.....	105.28	.....	341.54
11	13.84	184	1,132.27	579.99	678.85	155.87	2,546.98
9	12.18	620	3,219.79	1,785.61	2,086.47	460.35	7,552.22
10	9.22	366	1,064.87	1,461.81	620.84	225.63	3,373.15
5 and 8	9.58	917	3,461.52	2,417.68	2,395,44	511.25	8,785.89
Total	.....	2,408	9,513.91	6,999.53	6,081.94	1,437.64	24,033.02

Statement of lands ditched and checked, season of 1888 *and* 1889, *on District No.* 4, *Kern County, Cal., in townships south, range east, Mount Diablo base and meridian (the different lands being described on left-hand margin by sections, townships, and ranges, the figures appearing in this order):*

[Inclosure No. 8.]

Location.	Ditched and checked.	Cost of ditches and checks in 1888.	Cost of ditches and checks in 1889.	Total cost of ditches and checks.	Rate per acre of total cost.
	Acres.				
Sec. 7, T. 26 S., R. 25 E	670	$9,402.00	$226.16	$9,628.16	$14.37
Sec. 8, T. 26 S., R. 25 E	560	5,058.12	1,313.39	6,371.51	11.38
Sec. 9, T. 26 S., R. 25 E	.....	.....	263.15	263.15	.....
Sec. 17, T. 26 S., R. 25 E	300	1,881.63	510.21	2,391.84	7.97
Sec. 18, T. 26 S., R. 25 E	520	5,154.21	245.23	5,399.44	10.38
Sec. 19, T. 26 S., R. 25 E	.....	.....	42.15	42.15	.....
Sec. 21, T. 26 S., R. 25 E	.....	.....	35.40	35.40	.....
Sec. 22, T. 26 S., R. 25 E	160	.....	72.04	72.04	.....
Sec. 22, T. 26 S., R. 25 E	160	.....	129.03	129.03	.....
Sec. 23, T. 26 S., R. 25 E	80	.....	136.10	136.10	.....
Sec. 27, T. 26 S., R. 25 E	156	.....	158.80	158.80	.....
Sec. 29, T. 26 S., R. 25 E	257	.....	39.56	39.56	.....
Sec. 32, T. 26 S., R. 25 E	.....	.....	6.00	6.00	.....
Sec. 10, T. 26 S., R. 24 E	160	1,650.82	22.46	1,673.28	10.47
Sec. 11, T. 26 S., R. 24 E	480	5,267.79	185.03	5,452.82	11.36
Sec. 12, T. 26 S., R. 24 E	640	7,465.21	141.23	7,606.44	11.88
Sec. 13, T. 26 S., R. 24 E	560	3,402.47	163.87	3,566.34	6.37
Sec. 24, T. 26 S., R. 24 E	320	3,144.85	253.80	3,398.65	10.62
Sec. 1, T. 27 S., R. 24 E	500	5,965.83	130.76	6,096.59	12.19
Sec. 5, T. 27 S., R. 25 E	.....	.....	186.53	186.53	.....
Sec. 6, T. 27 S., R. 25 E	.....	.....	196.17	196.17	.....
Sec. 8, T. 27 S., R. 25 E	.....	365.40	.....	365.40	.....
Sec. 13, T. 28 S., R. 25 E	560	283.39	4,158.36	4,441.75	7.93
Sec. 14	640	335.99	5,250.05	5,586.04	8.73
Sec. 15	640	3,644.06	108.01	3,752.07	5.86
Sec. 5, T. 29 S., R. 27 E	629	.....	6,979.44	6,979.44	11.09
Sec. 9, T. 29 S., R. 27 E	200	.....	2,684,22	2,684,22	13.42
Sec. 10, T. 28 S., R. 27 E	104	.....	1,965.31	1,965.31	18.90
Sec. 31, T. 28 S., R. 27 E	534	.....	6,640.09	6,640.09	12.44
Sec. 32, T. 28 S., R. 27 E	.....	.....	.....	.....	.....
Sec. 15, T. 28 S., R. 26 E	Surveys.	.....	62.98	62.98	.....
Sec. 16, T. 28 S., R. 26 E	...do	.....	176.04	176.04	.....
Sec. 23, T. 28 S., R. 26 E	640	.....	2,485.33	3,485.33	3.89
Sec. 24, T. 28 S., R. 26 E	Surveys.	.....	306.09	306.09	.....
Sec. 25, T. 28 S., R. 26 E	380	.....	4,607.62	4,607.62	12.12
Sec. 36, T. 28 S., R. 26 E	426	.....	2,625.67	2,625.67	6.16
Total	10,276	53,021.77	42,506.28	95,528.05	.....

RESULTS SHOWN BY FOREGOING STATEMENT.

Acres ditched and checked	16,276 4,710
Cost	$95,528.05 51,575.07
Average per acre:	
Finished and unfinished	9.30
Finished sections only	10.95

DESCRIPTIVE OF IRRIGATION AS CONDUCTED IN KERN COUNTY.

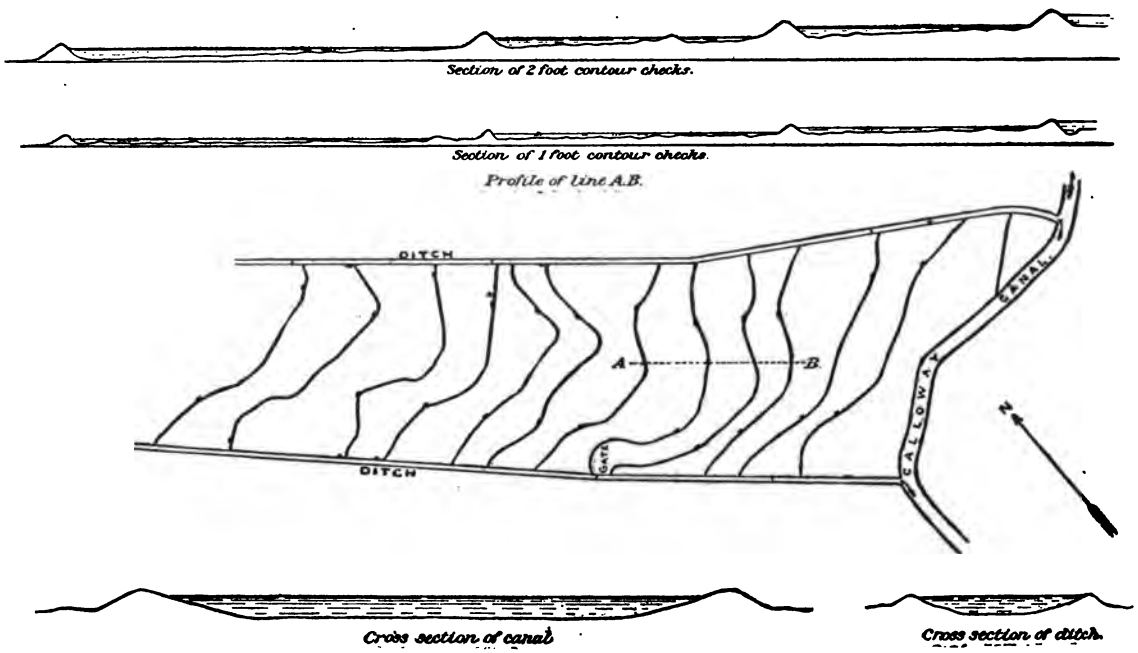
[Inclosure No. 9.]

There are four general classes of irrigation as conducted in California.

FIRST METHOD.

Constituting irrigation of vines and trees, as practiced in some portions of Los Angeles and San Diego counties, under which the water is conducted through pipes having openings at each different vine or tree to be irrigated, all of these small distributing pipes being supplied from one large pipe. This of course is a highly expensive mode of irrigation, and one which can not be practiced except where an exceedingly small amount of water must be utilized to the greatest degree possible and where the results as derived therefrom are of great benefit.

PLAN SHOWING SYSTEM OF IRRIGATION.



SECOND METHOD.

By building ditches at stated distances apart, the land being irrigated by the seepage or percolation of water through the soil, from one ditch to another. This method is applicable only in districts having a loose soil, through which the water can easily pass, and is not to any extent valuable for use in Kern County, where such conditions do not exist.

THIRD METHOD.

By building the ditches on the ridges or highest ground in the land to be irrigated, and from them running the water downhill and holding it back by means of small temporary checks, or, in cases of vines or trees, running the water downhill through plow furrows. This method of irrigating is well adapted to the irrigation of orchards and vineyards, thereby utilizing the water to good advantage; but in the irrigation of grass or alfalfa land, or in other cases where it is desirable to cover simultaneously a large area of land, it has been found to be more expensive than, and in the irrigation history of Kern county, has generally been supplanted by, the fourth method.

FOURTH METHOD.

By building ditches at stated distances apart, running downhill with the slope of the country, and between them building permanent levees on contour lines, the latter being distributed with the grade at varying distances of fall, as desired, of 6, 9, 12, 18, or 24 inches. This is the cheapest method of irrigating where there is an abundance of water, and where the area owned, controlled, or irrigated by any one man, is large.

The above descriptions under the first, second, and third modes of irrigation clearly indicate the manner in which the water is handled, and to the uninitiated no explanation is therefore needed, except as connected with the fourth mode, which has most generally been adopted in Kern County. In the second, third, and fourth modes of irrigating the diversion of the water from the river, creek, spring, reservoir, or other general source of supply where large areas are to be irrigated is required to be made into one general conducting ditch, from which the smaller distributing ditches diverge, conducting the water to the lands to be irrigated.

In order to clearly understand the mode of controlling and diverting the water from the river, attention is called to the "bird's-eye view of one system of irrigating as operated in Kern County, Cal.," mentioned in the list of Kern County photographs sent to Maj. John W. Powell, United States Geological Survey, Washington, D. C., as photograph No. 3, which shows Kern River, the Calloway Canal proceeding therefrom, the Calloway in turn supplying a couple of distributing ditches, which latter make delivery of the water within the restraining checks, thus accomplishing irrigation under, what is termed as above, the fourth method.

In the river, at the head of the Calloway Canal, as shown in photograph No. 13, as described in the above-mentioned list, is located what is known as the Calloway Weir, crossing the river from bank to bank and offering, when desired, an effectual barrier against the water flowing further down the river bed, which is accomplished by dropping what are known as weir boards into grooves provided in the upright standards of the weir, thus making a solid dam of 2-inch planking.

At times of abundant water it is unnecessary to employ the weir, for from the vast flood of waters, filling the river banks nearly to overflowing, sufficient water is swept through the canal headgate to supply the quota which should there be diverted. But when the flood lessens, as is the case in most if not all irrigating rivers, then without man's control the waters would be retained in the river bed, leaving the canal quite dry.

At such times it was formerly the practice in Kern County to construct what were termed wing-dams, made of sand and brush, and running out into the channel of the river at an acute angle up the stream, which served to turn into the canal its portion of the down-coming waters. But at best these weirs were but temporary affairs, often broken or washed away, until of late years it has been the policy to construct lasting weirs across the river, which can be regulated with ease and rapidity.

When the flow of water in the river lessens, requiring such action, the weir boards are placed in position in the river weir, "backing up" (or raising the level of) the water above the weir and causing it to enter the head-gate of the canal.

In the same manner there are oftentimes, when necessary, weirs in the canal, which after the same fashion turn the water into the distributing ditches, there being three such weirs in the Calloway Canal.

Where necessary on account of the "fall" of the country, and in order to preserve an even grade in the ditches, the distributing ditches are provided with "drops," allowing the water to make its descent to the new grade. These drops are provided

with a superstructure above the line of the water, as shown in the cross section in photograph No. 3, provided with weir boards similar to the other weirs; thus these drops serve to divert the water from the distributing ditches through the "side gates" of the ditches, above those drops, on to the land inclosed by the contour checks, thus accomplishing the actual irrigation.

As a further explanation in this same connection reference is made to inclosure No. 2, "Plan showing system of irrigation in Kern County, Cal.," on which appear cross sections of the main canal and the distributing ditches, and also cross-sections of land in process of irrigation under a system of "1-foot contour checks" and under a system of "2-foot contour checks," in which latter the inequalities of the ground are made to appear, with the blue shading representing the water. A portion of the main canal, a couple of distributing ditches, and the various contour checks are likewise shown. The checks are run on a level and thus, at regular intervals, act as dams to back the water over the space intervening between the check so constituting the dam and the next check above. When the irrigation in one check is completed the surplus water from that check is conveyed to the next check below, the balance of the water required being supplied from the distributing ditch.

Such is an explanation of the system of irrigation most general in Kern County, Cal. It is slightly varied in some respects on different ranches, but the general system is in every case the same, resulting in complete control of the water, from the time it approaches the canal head-gate in the river until it is drawn off in surplus from some irrigated check.

In "Memorandum of lands seeded to corn and alfalfa," under date of August 28, 1889, it it shown that the cost of the ditching and checking of the lands embraced in that statement amounts to an average cost of $10.95 an acre, and as explained in the same statement, these lands are situated about 25 miles from Kern River, and that average cost of $10.95 an acre does not embrace the cost of the main canal, carrying the water from the river for use in distribution amongst the various distributing ditches.

The average cost per acre as against lands irrigable from such a main canal as the Calloway, would be from $2 to $4 an acre, including cost of river weir, head-gates, canal weirs, etc., thus raising the average cost per acre of the irrigating works to a total of from $12 to $15 per acre. Thus it is seen that, whereas the expenditure of that amount is insignificant as compared with the value of the land with its then created productiveness, from the fact that the expenditures on the main canal are distributed amongst vast areas, on the other hand, were any one irrigator compelled to construct such a main ditch from the river to his small quantity of land, it would be impossible for him to limit his expenditures within any bounds of possible profit.

In connection with this same subject, see inclosure No. 2, with explanations concerning the same.

ACRES OF LAND SEEDED TO CORN AND ALFALFA, POSO DISTRICT, KERN COUNTY; SEASON OF 1888–'89.

[Inclosure No. 10.]

	Acres.	Average cost per acre.	Total cost.
Ditched and checked	16,276	$10.95	$178,222.20
Plowed	11,085	1.50	16,682.70
Seeded to wheat and alfalfa	5,536	6.05	33,625.77
Seeded to alfalfa alone	1,016	4.82	4,903.53
Seeded to Egyptian corn	4,513	1.85	8,370.53
Clearing on ground not seeded	11,085		633.22
Total			42,437.95
Of above—			
Clearing on ground not seeded			633.22
Ditched and checked and not seeded	5,191	10.95	56,841.45
Ditched and checked on land seeded to wheat, alfalfa, and corn	11,085	10.95	121,380.75
On ground seeded, cost of all work except ditching and checking	11,085	5.74	63,582.80
			$242,438.23

From the above figures will be noted the expensive irrigation works that are *required before* a crop can be obtained, which figures are applicable to operations on *virgin soil* that in one season was furnished with supplying and distributing ditches,

was checked, irrigated, reclaimed from its former arid state, and made productive and profitable.

The same figures demonstrate, however, that on the land ditched, checked, and cultivated, out of a total expenditure in accomplishing these results of $184,963.55 the cost of the reclamation works amounted to $121,380.75, or, in other words, and in round numbers, for every dollar spent in putting in the crop it was necessary to spend $2 to construct the irrigating works. This proportion is figured on the totals, including the varying crops of alfalfa seeded with wheat, alfalfa seeded alone, and Egyptian corn seeded alone, and, as the cost of the alfalfa seed is high, and to show the proportion between cost of ditching and checking and the cost of planting of each different crop, the following figures are brought into comparison:

	Wheat and alfalfa.	Alfalfa alone.	Egyptian corn.
Cost per acre for ditching and checking	$10.95	$10.95	$10.95
Cost per acre for planting crop	6.05	4.82	1.85
For each dollar expended in planting crop an expenditure for ditching and checking of	1.81	2.27	5.92

This thorough and complete though expensive class of irrigation works has been found quite necessary, for on the thirsty plains of the lower San Joaquin Valley water must be thoroughly distributed, even like nature's irrigation distributes the falling rain drops. It is also necessary to be able to rapidly flood and as rapidly drain the various checks, or otherwise the crop will be parboiled and killed from the unity of the water and the torrid sun. Hence embankments (or checks) for retaining the water, ditches to distribute and carry it away, and many flood-gates, drops, weirs, and other similar structures to control its flow are of necessity required.

The lands of which the above figures show the cost of ditching and checking are situated about 25 miles from Kern River, the fountain head of Kern County irrigation, and the figures do not embrace the cost of the main canal, which carries its flood of water for distribution amongst them in excess of a hundred smaller distributing ditches. The cost of carrying the water over many miles, if applied to any limited area of land, would be so excessively heavy as to preclude any possibility of profit; hence the reclamation of these arid tracts, distant from a water supply, can be effected only by some such means as are employed in Kern County, Cal., where the many miles of ditches are all under one intelligent management, to which the various lands supplied with water pay their tribute in most moderate water charges.

The expenditures thus made in the construction of the main canals, together with the other reclamation works, as heretofore explained, constitute the farmer's capital, on which, though heavy at first, irrigation multiplies adequate profits, with which come increased population, civilization, and homes, with all other changes consequent upon the transformation scene from desert to garden, from arid thirst to bending grain fields, sweet-scented hay, and heavy-laden orchards.

On the other hand, when the enduring, substantial nature of these works is considered, and when it is considered what a small percentage of additional cost is applicable to any one crop produced through such means, and on the other hand with an assurance of adequate water at the particular period when necessary to the proper nurture of the crops, and with absolute reliance against an oversupply, with a most productive soil compelled by irrigation to obey man's every wish, the original cost of the irrigation works as compared with the profits to be derived therefrom can be compared with the first crop which a husbandman would lose elsewhere through an insufficiency of rain, except that the one assures profit and the other loss.

MEMORANDUM CONCERNING PLAT SHOWING LOCATION OF HAY-STACKS AT POSO, 1889.

[Inclosure No. 11].

The plat represents a portion of what is known as the Poso district, in Kern County, and shows the locations of the various hay-stacks, the result of the cutting of hay made in the summer of 1889 on lands which, during the previous winter and spring, were, by J. B. Haggin and his associates, ditched, checked, and planted in wheat and alfalfa, and transformed, through irrigation, from an arid, unproductive, unprofitable condition to a verdant field of alfalfa.

The total acreage seeded to wheat and alfalfa, as shown by this map, amounts to.....acres 5,556
From which grain hay was cut and stacked, in the locations as shown on the map, to amount of.....tons 14,919
Therefore giving an average to the acre of hay to amount of.....tons 268,100
Out of 6,572 acres seeded to wheat and alfalfa, and alfalfa alone, a good stand of alfalfa was obtained on.....acres 6,083

Giving a percentage of crop lost of only 7 per cent., the season being one of the worst known for ten years.

This plat was made for use in the office of the Kern County property, to show the numbers of the stacks, as a reference to their tonnage as spread upon the hay records, and also as an index for office use, indicating the foremen who put up the various stacks. At the same time, as connected with the productiveness of irrigated lands, it is interesting from the fact of indicating, from the proximity of the stack locations one to the other representing a total of nearly 15,000 tons of hay, the wonderful quantity of hay obtainable under proper irrigation.

The reclamation and irrigation of the arid lands of Kern County, which lands up to the present time have been principally devoted to the raising of stock on alfalfa, has been most immediately made profitable through the hay production, demonstrating the productiveness of the soil and proving the correctness of the irrigation methods.

For a more thorough explanation in this same connection see inclosure No. 12, headed "Memorandum of hay cut, season of 1889, on Kern County property," etc.

MEMORANDUM OF HAY CUT SEASON OF 1889 ON KERN COUNTY PROPERTY AND REMARKS ON IRRIGATION.

[Inclosure No. 12.]

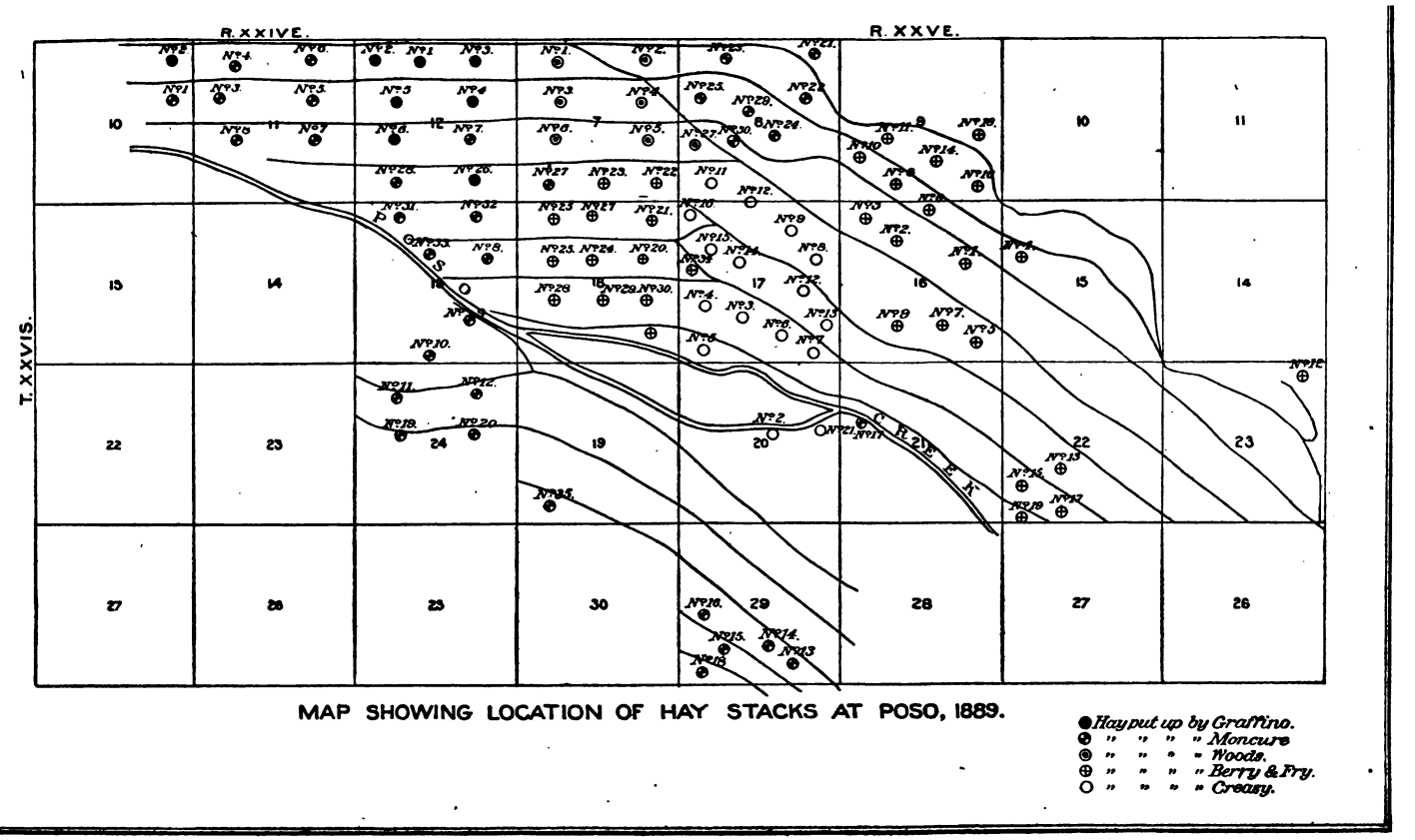
Memorandum of all hay produced.

	Alfalfa hay.	Grain hay.
	Tons.	*Tons.*
Stockdale ranch	611	.....
Cotton ranch	392	43
Anderson ranch	612½	.....
Cuyama ranch	183	.....
Mountain View dairy	675½	.....
San Emigdio ranch	60	.....
Bellevue ranch	1,658	.....
Hop ranch	228	.....
Rosedale ranch	604	.....
Greenfield's ranch	2,606	.....
Lakeside ranch	1,613	108
McClung ranch	782½	.....
Poso district	1,118	14,919
Buena Vista ranch	993	448
Total	12,136½	15,516
		12,136½
Total tons produced	.....	27,652½

As per hay statement, August 29, 1889.

As regards the lands in the Poso district, the records show that for the season of 1888-'89, and subsequent to the completion of the hay cutting, the pasturing of the same lands by cattle was commenced between the 6th and 16th of July, 1889, on which same lands the ditching and checking were done in September, October, November, and December, 1888; the clearing and plowing were done in November and December, 1888, and the harrowing, cultivating, and seeding were done mostly in December, 1888.

Poso District.—The total acreage seeded to wheat and alfalfa, as shown by statement inclosed, amounts to 5,556 acres; from which, as shown above, cut grain hay to amount of 14,919 tons, therefore giving an average to the acre of hay to amount 2.68 tons. Out of 6,572 acres, total seeded, a good stand of alfalfa was obtained on 6,083 acres, giving a percentage of crop lost of only 7 per cent., the season being one of the worst known for ten years.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MAP SHOWING LOCATION OF HAY STACKS AT POSO, 1889.
● Hay put up by Graffino.
⊕ " " " " Moncure
◉ " " " " Woods.
⊕ " " " " Berry & Fry.
○ " " " " Creasy.

A statement (R. P. O. 1247) showing all debits and credits against the land seeded to wheat and alfalfa, demonstrates the following:

Ditching and checking 6,572 acres at $10.95		$10.95
Putting in crop—		
Wheat and alfalfa, 5,556 acres at $6.05		6.05
Alfalfa alone, 1,016 acres at $4.82.		
Getting off crop, 5,556 acres at $4.31		4.31
Total debit		21.31
Credits:		
Yield of hay, 2.68 tons, at $6	$16.08	
Value of pasturage, say six months, at 25 cents per acre	1.50	
Total credit		17.58
Debit balance representing net cost of ditches and checks and of stand of alfalfa		3.73
Add one year's interest on net amount invested at 10 per cent		.37
Total cost at end of first year of 1 acre alfalfa land		4.10

On the same land the second year's operations could easily be made to show the following:

Debits:		
Net cost ditches and checks and alfalfa on 1 acre alfalfa land		$4.10
Add one year's interest at 10 per cent		.41
Three irrigations (two or even one would probably be sufficient) at 3 cents		.09
Cost of cutting 4 tons alfalfa hay, at $1.50		6.00
Total debit		10.60
Credits:		
Value 4 tons hay, at $5	$20.00	
Value eight months' pasturage, at 25 cents	4.00	
Total credit		24.00
Net credit balance at end of second year		13.40
The profits of the second year, $13.40, representing at 10 per cent. interest on a valuation of the property of	per acre..	134.00
Estimated valuation	do....	100.00
Leaving balance of amount invested on which interest can be earned as above to represent value of dwelling, barns, outhouses, fences, wells, cattle, sheep, horses, poultry, etc. (the live stock earning interest on their own valuation)		34.00

On a farm of 160 acres this additional investment of $34 per acre would amount to 5,440, a sum more than sufficient for such requirements.

Thus it is seen that under such a system of irrigation it is more than possible to receive, within the first and second years, return of the original investment and interest on a valuable estate.

The cutting of a total of more than 27,000 tons of hay in a district of country which fifteen years ago would not produce 27 tons, the miles upon miles of verdant green, housands upon thousands of cattle, horses, sheep, hogs, fat and contented as they crop the waving grass, the avenues of tall and stately trees bending their refreshing hade as against the noonday sun, the orchards of deciduous and citrus fruits, vineards of bright-hued grapes, the immense stacks of hay, warehouses full of grain telling of reserve forces for man and beast, the whirring mills grinding that grain for home se and shipment, the dairies with their heavy laden trucks of sweetest butter, their helves upon shelves of new-made cheese, the thriving towns busy with an empire's rade, the homes of happy faces, happy children telling the story of thrift and plenty, ontentment and prosperity, the every possibility, every inducement for a thousand uch homes where there is now one, for a kingdom where there is now a county, all nd each of these proceed from one common cause, but one lever moved them all nto being and that was water—water proceeding from Whitney's snow-clad peaks,

running its noisy, wandering course over many a mountain mile, restrained and made the servant of irrigation, has evolved the present Kern County from the wild, barren waste which possessed the same soil, same water facilities, but knew naught of irrigation.

In connection with this same subject, see inclosure No. 11, map headed "Map showing location of hay-stacks at Poso, 1889."

LIST OF PHOTOGRAPHS, TAKEN IN KERN COUNTY, SENT TO MAJ. JOHN W. POWELL, U. S. GEOLOGICAL SURVEY.

[Inclosure No. 12.]

No. 1, map of a portion of Kern County, showing river, irrigating canals, distributing ditches, and territory between Kern and Buena Vista Lakes to the north line of the county, and showing the locations of the various ranches, also locations of the towns of Bakersfield, Lerdo, Poso, and Delano.

No. 2, map of a portion of Kern County, on a scale larger than that of No. 1, showing most of the same features.

No. 3, bird's-eye view of irrigating as operated in Kern County, showing the river, the main canal (the Calloway), and distributing ditches, checks to restrain the water, and cross-section of distrjbuting ditch, weir, and river weir, together with locations of weirs and side-gates and distributiug ditches and flood-gates in contour checks, demonstrating mode of handling the water.

No. 4, view on the Calloway Canal near Poso, showing the volume of water required for the irrigation practiced in that district.

No. 5, view on the Calloway Canal near Poso, showing an irrigated alfalfa field on the left-hand side of the picture, together with the many cattle that it supports and stacks of hay produced therefrom, and in the distance to the right showing the unirrigated land, with its lack of all verdure; also showing the large canal and volume of water required for irrigating.

No. 6, view on Calloway Canal near Poso, showing on the right-hand side an irrigated alfalfa field with its many cattle, and on the right near the foreground an unirrigated patch of land with its few stunted trees, supported by the seepage of the canal, and on the left-hand side the unreclaimed arid lands, which, lacking irrigation, are devoid of vegetation, wholly unproductive, and unprofitable.

No. 7, view down Kern River from bluffs near Bakersfield, showing in the foreground a canal taking its water from Kern River and to the right of that the river itself, and further on in the distance a body of unirrigated, unreclaimed, and arid land.

No. 8, view up Kern River near the mouth of its cañon, with waterfall to the left, tumbling into the main body of the river—the source of all of the productiveness of Kern County.

No. 9, view of Pioneer bridge and weir, Kern River, Kern County. This picture is taken at a time when the Kern River contains an ample volume of water, most of the boards in the weir being withdrawn, allowing a full flood of water to pass the weir and flow down the river to supply the various irrigating ditches below.

An idea can thus be obtained as to the volume of the river from the water pouring over the weir. It will also be remembered that many ditches divert water from the river above this point; but before this system of irrigating was introduced the water of this river ran finally into Tulare Lake, breeding nothing but miasma and leaving the vast body of Kern Valley arid and unproductive.

No. 10, view of Pioneer bridge and weir. This picture is taken at a time when there is a smaller flowage of water in the river, and consequently the weir-boards in the weir are raised to a greater height, thus backing the water up and into the Pioneer Canal, and allowing a smaller quantity to pass below the Pioneer weir.

No. 11, Pioneer head-gate and bridge, Kern County. The same bridge is shown that appears in pictures 9 and 10, and besides is shown the Pioneer head-gate, which is under the bridge on the left-hand side of the picture. The water in the Kern River, being backed up by the river weir to the right-hand of the large bridge on the right-hand side of the picture, and which weir in this view does not appear, is diverted through the Pioneer head-gate on the left-hand side of the picture into the Pioneer Canal for irrigation on what are known as the McClung and Buena Vista ranches. (For further explanation of this matter see statement headed: "Descriptive of irrigation as conducted in Kern County, Cal.")

No. 12, view of the Calloway Weir, Kern County. This is the river weir which serves to control the water used by the Calloway Canal for irrigating the large body of lands to the north of Kern River, the water being similarly handled as explained

regarding pictures 9 and 10. The length of these weirs, which weirs cost from $20,000 to $30,000 each, can be appreciated from the pictures.

No. 13, view of Calloway head-gate and weir, Kern County. Near the center of the picture is shown the abutment dividing the river from the Calloway Canal. On the further side of this abutment and to the opposite bank extends the river Weir, which being closed by the weir-boards restrains the water from running down the river itself, which in the picture appears comparatively dry, turning it into the Calloway Canal, in the front of the picture, and allowing it to run through and over the Calloway head-gate, also appearing in the front of the picture, thus handling, with ease, the large volume of water which the river contains and turning it to profitable account. (In this same connection see remarks in statement headed: "Descriptive of irrigation as conducted in Kern County, Cal.")

No. 14, ditching and checking near Poso, Kern County. This picture represents a force of men engaged in the construction of ditches and checks preparatory to the reclamation and irrigation of these arid lands. The entire lack of verdure in this picture, when compared with some of the preceding pictures showing the irrigated and reclaimed lands, demonstrates most forcibly the absolute necessity of irrigation, and the most astonishing results proceeding therefrom.

No. 15, front view of Bellevue cottage on Bellevue ranch, Kern County, showing evergeen and deciduous trees, young orange-trees, blue-grass, etc. The blue-grass shown in the picture was, at the time the photograph was taken, not more than five months old from the date of seeding, thus demonstrating the productiveness of the soil under proper application of water.

No. 16, view of grounds at Bellevue ranch, Kern County, showing lombardy poplars of about ten years' growth, and through and between them the Bellevue vineyard.

No. 17, side view of Bellevue cottage, Bellevue ranch, Kern County, showing blue-grass as described in picture No. 15; also, young orange-trees. None of the larger trees in view are over ten years old.

No. 18, view of a portion of Mr. John Barker's ranch on the upper waters of Kern River, showing to the left the irrigated land, and to the right the unproductive arid land, which lacks irrigation.

No. 19, view at Miller & Lux's headquarters on the Buena Vista farm, Kern County, showing view of their irrigating canal, and in the farther left-hand direction, arid, unirrigated lands, supporting merely stunted sage-brush, and also their luxuriant corn and vegetable gardens, lately started, and not yet fully sprouted, to the right-hand of the picture.

No. 20, alfalfa fields, Kern County, showing view in the hay field, demonstrating the ample hay produced through irrigation, and showing several hay-stacks, representing the product of these alfalfa fields. A crop of hay such as represented in this picture will grow and mature in about six weeks.

No. 21, alfalfa fields, Kern County, showing luxuriant growth of alfalfa, affording sustenance for many cattle, and also demonstrating, by comparison of size, the large amount of hay afforded by these lands, under proper irrigation.

No. 22, view of alfalfa field in Kern County, showing a scene of reclamation and irrigation, results therefrom, and one of the distributing ditches, carrying the life-giving waters of Kern River.

No. 23, fig-tree on Tejon ranch, Kern County.

No. 24, hay scene at Messrs. Miller & Lux's Buena Vista farm, Kern County, showing manner of placing hay in stack.

No. 25, view of harvesting wheat and alfalfa hay in Kern County, showing luxuriance of its growth, ample quantity of hay afforded, and manner of stacking the same, on ground which not more than six months prior to the taking of the picture was unditched, unchecked, unirrigated, unproductive, and wholly arid.

No. 26, view similar to picture No. 25, showing a like crop of wheat and alfalfa, raised on lands similarly and in the same period reclaimed.

No. 27, "Late George Cling Peaches" as produced in Mr. Wible's eighteen-months'-old orchard, Kern County, showing actual size of box and fruit.

No. 28, "Orange Cling Peach," in the Maul orchard, Kern County, showing ladened trees and luxuriant fruit.

No. 29, "Orange Cling Peach," natural size, Maul orchard, Kern County.

No. 30, Wible's peach orchard, Kern County, showing his eighteen-months'-old trees, a photograph of the fruit, from which has already been shown in picture, No. 27, demonstrating the most satisfactory and profitable culture of peaches on lands which but for the artificial distribution of water would be utterly worthless.

No. 31, photograph of Kern County exhibit in the twenty-fourth industrial fair of the Mechanics' Institute, held at San Francisco, in August and September, 1889. Attention is called to the size and beauty of the fruit exhibit, both dried and fresh, as suggestive of the great possibilities awaiting the further development of Kern County under the continuation of its system of irrigation.

No. 32, another view of the Kern County exhibit, as shown in photograph No. 31, showing corn, cheese, fruit, grapes, alfalfa, hay, etc., produced in Kern County.

No. 33, another view of the Kern County exhibit at the Mechanics' Fair, as shown in photographs 31 and 32.

Framed photographs are likewise sent as follows:

First photograph, No. 953, view on the Calloway Canal, and alfalfa pasture fields, showing volume of water required for irrigation in that district, and results therefrom, as affording sustenance to the many cattle represented in the picture, as well as affording reserve feed in the hay-stacks, as shown.

Second photograph, No. 949, harvesting wheat and alfalfa irrigated from the Calloway Canal, in Kern County. (See description under photograph Nos. 25 and 26.)

Third photograph, No. 951, the Calloway Canal and alfalfa pasture fields, showing the results of irrigation as practiced in Kern County.

Fourth photograph, No. 955, the Calloway Canal and alfalfa pasture fields, showing results of irrigation in Kern County.

Also are inclosed Volumes A, B, and C, photographic views of Kern County, in which a short description of the view represented is affixed to each picture.

MEMORANDUM RELATIVE TO PRODUCTS RAISED AT VARIOUS TIMES IN KERN COUNTY.

[Inclosure No. 15.]

These consist of cotton, rice, tobacco, alfalfa, and vegetables (all kinds).

Cereals—Wheat, barley, oats, corn (Indian and Egyptian), and rye.

Orchard fruits—Apples, pears, and figs.

Pomegranates.

Stone fruits—Plums, apricots, peaches, cherries, and nectarines.

Vines—Hops, grapes, and melons.

Berries—Strawberries, raspberries, blackberries, and mulberries.

Nuts—Pecan, walnuts, almonds.

Citrus fruits—Oranges.

Live stock—Horses, jackasses, mules, cattle, sheep, hogs, and goats.

The different products as above enumerated have at various times been raised, and with complete success.

All of the cereals are produced abundantly; the seeded and the stone fruits are of an especially good quality, and the same may be said of grapes, a considerable body of Kern County land being particularly suitable for these latter products.

An excellent quality of cotton has been raised, and upland rice has done remarkably well. The tobacco produced has been luxuriant. Alfalfa has been a product largely raised. It has been remunerative, and from its growth and pasturage increases the productiveness of the lands.

Vegetables do remarkably well and are of most excellent quality, and make their appearance considerably earlier here than elsewhere in the State.

Whereas all of these products can be abundantly and remuneratively raised, their cultivation is absolutely precluded unless carried on under a system of irrigation, the lands being sterile without the artificial distribution of water.

A CLIPPING FROM THE KERN COUNTY CALIFORNIAN, A WEEKLY NEWSPAPER PUBLISHED IN BAKERSFIELD, KERN COUNTY.

[Inclosure No. 15.]

Kern County in 1867 *vs.* 1888.

Registered voters in 1867	751
Population	2,133
Assessed value of property	$1,150,417

In 1888 the record was as follows:

City and town lots	$406,667
Improvements on same	265,876
All other real estate	5,730,696
Improvements on same	400,270
Personal property	2,132,348
Southern Pacific Railroad Company	2,101,650
Atlantic and Pacific Railroad	12,492
Pullman Palace Car Company	1,067
Total assessed values	11,45[illegible],086

Acres assessed	1,079,698
Mortgages	401,674
Registered voters	2,715
Estimated population	10,000

These tables show that from 1867 to 1888, twenty-two years, taxable property has increased nearly tenfold, and registered voters show a gain of 360 per cent. The figures for 1867 were obtained by the courtesy of George W. McEwen, of Visalia, who at that time was assessor of this county.

Adjourned.

LOS ANGELES, CAL., *September* 1, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman), and Reagan; also Director Powell.

STATEMENT OF DON ANTONIO F. CORONEL.

The CHAIRMAN. How long have you resided in Los Angeles County?

Mr. CORONEL. Fifty-five years.

The CHAIRMAN. Did you practice irrigation while California was a part of Mexico?

Mr. CORONEL. All my life; ever since I have been here; for everything—cereals, grains, oranges, and fruits of all kinds.

The CHAIRMAN. Was there ever a time in the history of California when you could raise all the crops without irrigation?

Mr. CORONEL. Never have I planted anything without irrigation.

The CHAIRMAN. From what country did you come to California?

Mr. CORONEL. From Mexico.

The CHAIRMAN. Are you a native of Mexico?

Mr. CORONEL. Yes. I was born in the City of Mexico; I came here in 1832.

The CHAIRMAN. What was your age at that time?

Mr. CORONEL. I am now seventy-two years old, and that was fifty-five years ago.

The CHAIRMAN. Where you lived in Mexico they practiced irrigation?

Mr. CORONEL. Yes; I saw many places in Mexico where they used irrigation.

The CHAIRMAN. There is where you learned to irrigate?

Mr. CORONEL. Here is where I learned to irrigate; I was too young to practice irrigation in Mexico.

The CHAIRMAN. During the time that this State was a part of Mexico, did they pursue farming to any considerable extent?

Mr. CORONEL. We raised crops for families.

The CHAIRMAN. None of the products were for export?

Mr. CORONEL No; the business here was the raising of cattle. The farming was simply for home consumption.

The CHAIRMAN. They established farming, in the first instance, about the missions?

Mr. CORONEL. Yes.

The CHAIRMAN. The country was a stock country?

Mr. CORONEL. Yes; the Missions had farms—the old Fathers were farmers.

The CHAIRMAN. And they had fruit orchards?

Mr. CORONEL. Yes; they had large fruit orchards, and they came from the water.

The CHAIRMAN. What usage did they have for distributing the water? How did they determine who had the right to use it? In other words, what were the laws governing the use of water?

Mr. CORONEL. The same laws that govern here now. The Americans have followed the same system that they had.

The CHAIRMAN. The law of appropriation?

Mr. CORONEL. Yes. There have been some improvements in the ditches. They have put in pipes—modern improvements. But it is the same law of appropriation.

The CHAIRMAN. Do you think if the judges had obeyed the law you made for us we would be happy?

Mr. CORONEL. Yes, I think so.

STATEMENT OF H. W. PATTEN, OF LOS ANGELES.

The CHAIRMAN. What is your profession?

Mr. PATTEN. I am register of the United States land office.

The CHAIRMAN. Make any statement which you think would be of interest to the committee.

Mr. PATTEN. I have brought a map showing our land district, showing the land in the district—with the desert land marked off, defined.

The CHAIRMAN. You mean the land that may be reclaimed?

Mr. PATTEN. Yes; the land which we consider can be entered under the desert land act—land that will not raise ordinary crops without artificial irrigation. It is divided into three parts: The Antelope Valley, the Mojave Desert, and the Colorado Desert. I will also file a report showing the number of acres.

The CHAIRMAN. Have you the report with you?

Mr. PATTEN. Yes.

Senator REAGAN. Do you describe the various areas in your report?

Mr. PATTEN. Yes; they are thoroughly described. I find that we have 13,156,000 acres of desert land in this district that have not been reclaimed; of that the Mojave has 6,302,000, the Colorado 4,699,000, and the Antelope Valley 2,185,000 acres.

Senator REAGAN. What proportion of that land belongs to the Government?

Mr. PATTEN. Of that I should think that at least 12,000,000 acres belong to the Government.

The CHAIRMAN. Of the 13,000,000 acres?

Mr. PATTEN. Yes; and possibly a greater proportion will revert to the Government if it is not reclaimed.

The CHAIRMAN. They have attempted to reclaim it?

Mr. PATTEN. There have been 333,000 acres entered under the desert land act, from which the Government has received $99,617.05. That has been paid in this land district for such entries, and the number of the entries is 768, but only 23 persons have been able to prove up. I do not think the Government has parted with 6,627 acres out of the total 333,181 acres. The remainder has reverted to the Government, because of the failure of the parties to reclaim, or will fail because the work is too expensive for private enterprise.

The CHAIRMAN. Have you given any attention to the source of water supply for this land?

Mr. PATTEN. Yes.

The CHAIRMAN. Have you been over the Antelope Valley?

Mr. PATTEN. Yes.

The CHAIRMAN. Where is the water supply for the Antelope Valley?

Mr. PATTEN. It is surrounded on all sides by ranges of hills.

The CHAIRMAN. What hills?

Mr. PATTEN. Well, they are not thoroughly defined; they are not mountains.

The CHAIRMAN. Where is the Antelope Valley?

Mr. PATTEN. Eighty-five miles north of us.

The CHAIRMAN. This side of the mountains?

Mr. PATTEN. Yes.

The CHAIRMAN. The railroad goes through a portion of it, does it not?

Mr. PATTEN. Yes; here [indicating on a map] is the railroad line defined.

The CHAIRMAN. Have you examined the water supply for Antelope Valley, and seen what portions there are to irrigate portions of it?

Mr. PATTEN. Yes; I have examined it to some extent.

The CHAIRMAN. What do you say of it?

Mr. PATTEN. I think that the greater portion of the land up there could be reclaimed. I think that it could be done by building dams across these mountains and storing up water for use in the summer season. There is one very good place up there—Elizabeth Creek. Of that I think a good catchment basin could be made. There is another place—Oak Creek, There are some eighteen or nineteen men who have entered on Oak Creek. They have been asking the Government for an extension of the time to bring water on to the land.

The CHAIRMAN. Are you familiar with the Mojave Desert?

Mr. PATTEN. Not so familiar as I have been with the portion up here.

The CHAIRMAN. Has the Mojave River been utilized?

Mr. PATTEN. It has not been. I will file another map with you, showing where water could be taken out of the main branch of the Mojave River to irrigate some 30,000 or 40,000 acres of land. I will file that map. That is a natural basin, and I will state that a good deal of that land was entered under the desert land act, and it has reverted to the Government.

The CHAIRMAN. With regard to the Colorado River: Have you examined to see whether that could be taken on to this desert?

Mr. PATTEN. Well, only superficially have I examined it.

The CHAIRMAN. Have you been up above The Needles?

Mr. PATTEN. Yes. I think that water could be taken out.

The CHAIRMAN. If it could be, there is abundant land to absorb it all?

Mr. PATTEN. Yes; but it would be too expensive for anybody but the Government to undertake it.

The CHAIRMAN. We do not know yet. It will cost a good deal of money; but that will be determined later. How would you irrigate the Colorado Desert?

Mr. PATTEN. By building catchment basins and catching the water throughout those hills.

The CHAIRMAN. Is there anything else you wish to state?

Mr. PATTEN. No. I simply wished to file this map and statement with you.

The statement is as follows:

At the request of the president of the chamber of commerce of this city I take pleasure in submitting to you a few figures in regard to the desert lands of the Los Angeles land district.

The act of Congress under which you gentlemen are prosecuting your inquiries

would seem to, in a measure, confine your work to a consideration of the lands arid in character which still belong to, or are likely to revert to, the Government.

It is of such lands within the limits of the Los Angeles land district that I shall treat. My object will be to show you, by means of a map which I have had made, ranges of mountains containing many reservoir sites so sloped by nature that only supplemental work will have to be done by man to make them catchment basins of vast capacity; to show you the streams and water-sheds which will furnish the water for filling the storage reservoirs, and to show land lying under them belonging to the national domain upon which this water can be conducted, and thus the value of the lands be increased from nothing per acre to $100 per acre.

As to the cost of the work to be done by the Government in this district it is impossible for me to furnish an estimate, but it is not beyond my wildest hopes to convince you that the Government will receive in actual cash, through this land office, at the legal price for land, every dollar expended in the work done here, while at the same time $200,000,000 will be added to the assessment rolls of the several counties of this district.

As for the benefit of irrigation, other gentlemen will see to it that you are thoroughly informed, and visits to places where you will see land on one side of a ditch too high for the water to reach worth 75 cents per acre, and land on the other side of the ditch whereon water can be and is conducted worth $1,000 per acre, will have a very convincing effect.

Fortunately the Los Angeles land district contains more desert land susceptible of irrigation than all the rest of the State. I say fortunately, because now that the Government has taken this matter in hand our people have reason to believe that every acre of this now desert land will be reclaimed and put in a productive condition.

From a careful examination of the records of this office I find that in this district there are 13,156,000 acres of arid lands divided into three bodies:

	Acres.
Mojave Desert	6,302,000
Colorado Desert	4,699,000
Antelope Valley	2,185,000

These are lands which can be entered under the desert land act as lands "which will not without artificial irrigation produce agricultural crops in ordinary years." Under the provisions of this act a person can by paying 25 cents per acre on single-minimum land, or 50 cents per acre on double minimum land, enter not to exceed 640 acres; and if he conducts water on the same and reclaims it to such an extent that it will raise crops, he shall have the privilege within three years of proving up on said land, and by paying an additional $1 or $2 per acre, as the land may be single or double minimum, receive a patent therefor.

That there is much land of this character in the Los Angeles land district is evidenced by the fact that seven hundred and sixty-eight persons have found in this district 333,181 acres of land which they thought could be reclaimed, and have paid into the land office $99,617.05 in first payments for such entries. It may be surprising to know that out of the large number of entries—seven hundred and sixty-eight—only twenty-three persons have proved up, and the Government has only parted with title to 6,627 out of the total number of acres entered. The remainder of the 333,181 acres has either reverted to the Government because of the failure of the parties to reclaim, or will shortly revert because the work of reclamation is too expensive for private enterprise. To sum it up briefly, the Government has received from the people of the Los Angeles land district $92,989 for first payment on desert lands, and the Government still has the land.

In this connection I trust it will not be deemed indelicate to indulge in the hope that, inasmuch as the Government has secured this large sum from the people of this land district on account of desert lands, and the people have not been benefited thereby, a proportionate sum of the money appropriated for surveys be expended down here, and an investigation of our wants be made by the consulting engineers. It is a matter of reciprocity, and will be greatly to the advantage of the people and the Government.

It must not be taken as a discouraging sign that so few final entries of desert land have been made. It is purely a question of expenditure, and the class of people who seek to obtain title to land under the beneficent laws of the General Government are unfortunately not wealthy, and the reclamation of even a section of desert land is a work of some magnitude and considerable expense. What would be a comparatively easy task to the Government, where there are many thousand acres to be irrigated, becomes very onerous to the man who tries to put water on 640 acres of land.

Fortunately, however, the reclamation of desert land has been successfully tested *in this district*, and all difficulties have been met and overcome. In township 4 *north of* range 9 west two gentlemen of this city, Messrs. Rowan and Bent, entered

about 1,000 acres of desert land and proceeded to take water out of Big Rock Creek with which to irrigate it. When their proof was presented it showed that these gentlemen had expended over $10,000 in developing and piping water to the land claimed by them. I understand that they have lately sold their land for $30,000. This is land which cost $1.25 per acre, and which, after an expenditure of $10 per acre to get water on it, sold for $30 per acre—rather a good profit, and an investment that could commend itself to any careful business man. But when it costs a private individual $10 per acre to irrigate land, the Government could do it for $1 or less per acre, because the Government would deal with larger tracts.

About four years ago some gentlemen entered desert land and began developing water in Cottonwood Cañon, situated in township 10 north, of range 15 west. I paid a visit to the ditch when the water was turned into it and it was a sight to make the heart glad. There could not have been less than 1,200 inches of water flowing in the ditch, and where water was taken out and put upon experimental crops the effect was wonderful. But all this came to naught, for in the summer season the water ceased to flow and the crops died. Now, there was no question of the quantity of water, because it was superabundant in the winter season, and there was no question of its effects on the crops. It was simply a question of storage, and reservoirs could have been built and the water saved and brought into use when needed, but the funds of the company gave out, and the lands reverted to the Government. In my judgment, a reservoir could be constructed to store up the water flowing in that cañon, and by using it economically a supply sufficient for the irrigation of 50,000 acres of land saved.

In township 11 north of range 14 west, eighteen sections of desert land have been entered, and an effort made to get water out of Oak Creek with which to irrigate this land. The time allowed by law for reclamation has expired, and the gentlemen making these entries are to-day asking the Government for an extension of time of one year in which to comply with the law. If the Government had this work in hand it could build a dam and reservoir, catch the water of Oak Creek and reclaim one hundred sections of land in that vicinity. At the Government price of $2.50 per acre, the United States would receive $160,000, the land would be worth $2,000,000, and the country would be that much benefited.

The map which I present to you carefully defines the desert area. It also shows the mountain ranges surrounding these desert lands. In those mountains are innumerable cañons capable of being made reservoirs, and through them are thousands of acres of lands, now worthless, that with water would be of great value.

I don't think I am extravagant in saying that in this district there are 4,000,000 acres of land which can be reclaimed without extraordinary expense, and the people will cheerfully pay the Government $10,000,000 for these lands. The matter resolves itself into a pure business proposition. Can the Government afford to expend $5,000,000 in this district, receive a direct return of $10,000,000, and add $200,000,000 to the assessment rolls of southern California?

Mr. Patten also filed with the committee a map showing a natural basin in San Bernardino County, where water can be obtained from the Mojave River and stored up for use. Also full facts in regard to this particular basin. For this map and the accompanying description he was indebted to Mr. H. Y. Harding, civil engineer, of Los Angeles.

ON PROPOSED DITCH AND RESERVOIR SYSTEM IN TOWNSHIPS 3, 4, AND 5 NORTH, AND RANGES 2, 3, AND 4 WEST, SAN BERNARDINO BASE AND MERIDIAN, SAN BERNARDINO COUNTY, CAL.

The water for this system will be taken from the east or main branch of the Mojave River about 1 mile above its junction with the west branch. This stream is fed by heavy snows in the mountains, whose elevations are from 8,000 to 10,000 feet.

The dryest season includes the months of July, August, and September.

For several months in the winter the river contains from 30,000 to 50,000 inches of water. This water sinks about 1 mile below the junction of the forks and, for a distance of 15 miles, runs under the sand, returning to the surface again at Victor. The east fork is rocky and precipitous, and is fed by several additional small streams on the south side; shown on the plan in red. The distance to the reservoir site is from 12 to 15 miles. The first half of the work would be heavy and the last light. Estimated cost, say, $25,000.

The reservoir site is naturally fine, covering an area of 1,500 acres; depth 50 feet, and by the addition of a short dam of moderate height its capacity would be doubled.

It is to be remembered that for nine months in the year the reservoir can be drawn on for an unlimited quantity of water which would be constantly supplied from the river. A short tunnel on the west side would drain the reservoir to the bottom.

The land slopes to the north and west, and is well adapted for irrigation. There s at least 50,000 acres that could be supplied with water from the system.

The elevation is about 3,000 feet. The highest temperature in summer is 104°, with cool nights. Estimated rain-fall 8 inches. The soil is well adapted for the raisin grape, which has been successfully grown at Hesperia, and for a well-diversified system of general farming. As the engineer of the Hesperia water system, the writer speaks from experience, having passed about two years in the district. Mines of more than ordinary worth are being developed in the surrounding mountains, and the railroad gives assurance of a ready market for all products of the farm and mine.

STATEMENT OF E. W. JONES, OF LOS ANGELES.

The CHAIRMAN. You are president of the Los Angeles Chamber of Commerce, Mr. Jones?

Mr. JONES. I am, and I am well acquainted with the business interests of this county.

The CHAIRMAN. You have something to offer in regard to the different methods of water distribution in vogue here. Do so in your own way.

Mr. JONES. There are more systems of irrigation, more methods of application, more varieties of land irrigated, including mountain, foothill, bench land and valley, desert and habitable, more kinds of soil and crops, more valuable experience and information, than in all the rest of the country "put together." From the earliest Spanish-Mexican occupation to the present time, a period of more than a hundred years, the practice of irrigating has been a necessity, and the leading and distinctive feature of farming in this county.

The old Spanish methods still prevail here in some places, while every improvement and modification of them thus far invented is here to be seen in application. When one realizes that until irrigation was introduced here by the white race this region was regarded as irredeemable desert, fit only for the grazing of stock in a desultory way and during the rainy season, that the frequent drouths made that business a precarious one, and that without irrigation it would still remain so, some appreciation of the value of irrigation to arid regions can be had. When it is further realized that only by development by means of tunnels, artesian wells, and storage reservoirs can half our fertile lands be made habitable for human beings, and that these are beyond the means of ordinary private enterprise, the advantage and necessity of public aid becomes apparent.

The acreage in this county to which irrigation is actually applied is probably more than that of all the rest of the State put together. It is so situated that you can see much of it in the highest state of improvement, covered with every variety of crops, and under many different systems, in a comparatively few miles of very pleasant travel.

In Los Angeles County, then, the committee may see irrigation by means of earth canals with wooden gates, weirs, dams, flumes; open cement ditches; brick and stone, cement and iron pipe; conduits; subirrigation; lifting by wheels, windmills, and steam, gas, and hot-air engines, with pumps; flowing artesian wells (there are said to be 5,000 of these wells in this county alone, some throwing 4 to 7 inch streams 14 feet into the air); submerged and other dams; reservoirs of all sizes, some holding many million gallons, with every appliance for raising, distributing, and utilizing the beneficent fluid.

With all these methods in operation we feel assured that the committee's investigations will be in all ways profitable. We point with *pride* to our rapid growth. Within a few years from a population of

12,000 to one of 150,000, and that on an area reduced in size; a population more prosperous, too, than can elsewhere be found in our land.

STATEMENT OF B. S. EATON, OF PASADENA, LOS ANGELES COUNTY.

The CHAIRMAN. What is your profession?

Mr. EATON. I am a farmer.

The CHAIRMAN. How long have you resided in this county?

Mr. EATON. Fifty-one years.

The CHAIRMAN. How long have you been a farmer in Los Angeles County?

Mr. EATON. I have been a practical farmer for nearly the entire time.

The CHAIRMAN. By what means do you farm?

Mr. EATON. By irrigation entirely.

The CHAIRMAN. Can you produce all-around crops regularly without irrigation?

Mr. EATON. No; I can not.

The CHAIRMAN. Occasionally you can produce small grains without irrigation?

Mr. EATON. We can produce small grain. We raise it on the strength of the winter rains, and we get a good crop almost invariably. I do not think we have a failure once in ten years. All other crops here, on uplands, require irrigation.

The CHAIRMAN. What were the usages as to the distribution of water among the Spanish residents when you came here?

Mr. EATON. Entirely by appropriation.

The CHAIRMAN. How did they govern their relative rights?

Mr. EATON. Here in Los Angeles—I practiced irrigation in the city of Los Angeles twelve or fifteen years—we followed the practice that had governed under Mexican rule. Waters were diverted from the river and distributed through zangas. There were nine different tomas; now they are reduced to two. The general manner of paying for water was this: One man would give a sack of beans to the zanjero, or water-master. Each ditch had its water-master. We call him a zanjero, or water-storer. Our contribution consisted of what we raised.

The CHAIRMAN. You paid him for the use of the water?

Mr. EATON. Yes; and we would inquire of him what time he would give the water.

The CHAIRMAN. Did the right depend on the date of appropriation?

Mr. EATON. Not in those days. Do you mean for service?

The CHAIRMAN. Did you, when there was a conflict, determine by the principle of prior appropriation?

Mr. EATON. Not at all. We were served according to our turn on the ditches. It was supposed that we had plenty of water. At that time there were 2,000 acres under irrigation, and to-day there are 14,000 acres, and it is better served to-day than it was then. That is what intelligence does.

The CHAIRMAN. Your right depended on appropriation then, as it does now?

Mr. EATON. Yes; they appropriated the whole river.

Senator REAGAN. No one had a right above another to take his turn?

Mr. EATON. Yes. It was done at the expense of the city. They built a sand and brush dam. They have not advanced here.

The CHAIRMAN. They appointed a water-master for each ditch and they dealt the water out to the inhabitants?

Mr. EATON. Yes. If it did not reach us we had to get along the best we could.

The CHAIRMAN. And the Americans adopted the same regulations that were in existence under Spanish rule?

Mr. EATON. Yes.

The CHAIRMAN. And the usage of water depended on appropriation?

Mr. EATON. Entirely.

The CHAIRMAN. Without regard to whether they owned the land on the river or not?

Mr. EATON. We knew nothing of riparian rights.

The CHAIRMAN. That word is not a native of this country?

Mr. EATON. No; it has not been in vogue anywhere in the country. The streams that have been developed in the mountains have been under prescription, occupation, and use.

The CHAIRMAN. With what success could crops be raised here without irrigation?

Mr. EATON. Irrigation insures the farmer a certain crop.

The CHAIRMAN. What is a fair crop of alfalfa?

Mr. EATON. From 7 to 10 tons a year.

The CHAIRMAN. Do you raise corn?

Mr. EATON. Yes.

The CHAIRMAN. What is a crop of corn?

Mr. EATON. From 75 to 125 bushels to the acre?

The CHAIRMAN. What is a good crop of wheat?

Mr. EATON. It is raised without irrigation. I think an average crop of wheat is 20 sacks to the acre. I do not know whether the county would average that.

The CHAIRMAN. That would be something over 30 bushels to the acre?

Mr. EATON. I hardly think the county would average that; perhaps 25 bushels.

The CHAIRMAN. What would be a fair crop of oats?

Mr. EATON. We do not raise oats. It is hardly practicable to raise oats here.

The CHAIRMAN. How is barley?

Mr. EATON. The country is naturally adapted to it. I have known as high as 90 sacks to the acre; but 40 to 45 and 50 sacks to the acre is the average.

The CHAIRMAN. Of 100 pounds to the sack?

Mr. EATON. Yes.

The CHAIRMAN. What kinds of fruits do you raise here?

Mr. EATON. Any kind that can be raised in the temperate zone, and some of the tropical fruits. Everything in the citrous family, besides guavas.

The CHAIRMAN. You stated that there were 2,000 acres under irrigation when you came here, and that now there are 14,000 acres, and you have a better water supply. How do you account for that?

Mr. EATON. The water is better handled; the ditches are in a better condition, and the water is regulated from necessity. Formerly they did not economize, and they depended upon till. The old manner of raising crops was not to put the water on until June. They had a kind of corn that would perfect itself in ninety days. They would flood the ground with water, and then they would give it another irrigation, and then it was all right. I have seen 90 bushels to the acre of that.

The CHAIRMAN. You economize the water now?

Mr. EATON. We economize in various ways. They stir the ground,

pulverize it, and keep the surface in a perfect state of till, loose and pliable, so that it retains the moisture better. You see as you put water on the ground it dries and contracts and opens avenues for the moisture to escape. The systems have been very largely improved, so that the water is made to perform a much larger duty. Los Angeles has advanced in that respect.

The CHAIRMAN. Where have you best economized in this county?

Mr. EATON. Perhaps in Pasadena. The engineer gives us the credit of a higher duty there than anywhere in the State. There we make an inch of water accomplish more than anywhere else.

The CHAIRMAN. What do you think of the supply of Antelope Valley?

Mr. EATON. In this immediate neighborhood the Sierra Madre has afforded no facilities for storing in large quantities. I made a pretty thorough examination last year. The ridges there shape the valleys narrow, and the length on an average is one to five—one to four. Therefore a dam raised a foot high would only back it several feet. There is no lake surface, and you have to come down nearer the ocean.

The CHAIRMAN. Have you examined the Antelope Valley over these mountains?

Mr. EATON. I have been there. There they have two streams—Little Rock Creek and Big Rock Creek. They have considerable water at their sources. They are not utilized. The Little Rock Creek does not reach out into the country at all, and it is limited; Big Rock Creek could be made to serve two or three thousand acres.

STATEMENT OF GEORGE H. PECK, OF LOS ANGELES.

The CHAIRMAN. How long have you resided in Los Angeles?

Mr. PECK. Twenty years.

The CHAIRMAN. And are you a farmer by occupation?

Mr. PECK. I was a farmer in 1849.

The CHAIRMAN. Have you observed the water supply in this county?

Mr. PECK. Yes; very closely.

The CHAIRMAN. State what you know about the water supply of this valley in which Los Angeles is situated.

Mr. PECK. I will take it in a general sense. The average water-fall used to be 15 inches—a foot and a quarter. It has increased a good deal since then. That does not help us. But taking the average water-fall at a foot and a quarter on the plains you must take the water-shed also. If it be a foot and a quarter—15 inches—on the plains, you must estimate it is double 15 inches in the mountains. That makes 30 inches. That is my estimate. Then consider, as it is given in this very able report, that there is three times the water-shed that there is of arable land. Then there is a water supply from the mountains that covers 3 feet of water. That 3 feet is three times a foot and a quarter; that is to say, $3\frac{3}{4}$ feet, twice the rain-fall; that is to say, to double it makes $7\frac{1}{2}$ feet, and adding that to the plain-fall makes it $8\frac{3}{4}$ feet.

The CHAIRMAN. How are you going to save that water?

Mr. PECK. The only way we are going to save it is by these reservoirs, holding the water in the mountains.

The CHAIRMAN. These mountains are very precipitous. Have you examined them to see whether there is an opportunity to store the water?

Mr. PECK. Yes. It seems as if nature had made it on purpose for a reservoir. Men, with all the money that could be advanced, could not

make the reservoirs that are provided in the San Gabriel—the one that Mr. Hinton spoke of.

The CHAIRMAN. Have you been over that?

Mr. PECK. Not critically. There is something about Eagle Lake, and I think Mr. Hinton mentioned something about Elizabeth Lake. There is an excellent lake for a reservior. That is on one of the southern tributaries of the San Gabriel River. One man told me it was 6 miles long. I have not been there. I have been told it was 6 miles long. It might not have been over a mile, but it is fathomless.

I wish to say another thing. We have an immense volume of water, and while I am confident, if it could be stored, it would give us all the water we want, yet, in reply to your general talk about millions coming here, I would say we can not have the millions unless we have the water, and we can not have the water unless we have the reservoirs.

In the winter the San Gabriel has 80 inches of water on the mountains, and it comes tearing down sweeping away large bridges. The Southern Pacific had to rebuild their bridges three times. If this water could be stored it would save that damage that is done in the winter and we could have the water for irrigation purposes in the summer.

The CHAIRMAN. Do you think a survey, determining where and how that could be done, would be valuable?

Mr. PECK. Yes, I think so.

The CHAIRMAN. Our inquiry among other things is what would be the value of a survey? Would a survey in your opinion facilitate the development of the water?

Mr. PECK. I think so. There are ridges in those places, I am told, that will bear damming. I have not been up there—not all through there—and I have not investigated the matter.

Mr. HINTON. You think the San Gabriel is not doing one-third the work it should because it is not handled. If you go up the river you think you can get from four to six times the water that is used to-day. What is the value of the land after the water has been introduced?

Mr. PECK. Do you mean the marketable value?

Mr. HINTON. I mean the intrinsic value as an investment.

Mr. PECK. The parties who own the San Pascual ranch, with about 14,000 acres, sold 5,000 acres at $6 an acre and 4,000 at $24 an acre. They thought they had made a good sale, because as a pasture it did not pay the interest on the money. To-day that same land, with the water applied to it, wherever it is applied, is worth $250 an acre without exaggeration, and you can make it pay at that figure. I heard Mr. Wilson say that from 8 acres, with 600 orange-trees, they had taken $21,200 worth of oranges, and that for five years there was an average of $15,000 a year. That orchard pays about 10 per cent. on $2,500 an acre, and it is not extra fine. The land cost him $12 an acre.

There is another point that I had not thought of before, and that is, what it costs to put water onto the land when you have the water. I have built seven different systems. Our system is an iron-pipe system. I believe it was the first one ever conceived—distributing water through iron pipes for irrigation. The system answers the double purpose of furnishing a system for domestic purposes equal to any city in the United States, and at the same time for irrigation. That is the reason why our water does such high duty.

The CHAIRMAN. The water passing through these pipes saves it from seepage.

Mr. PECK. Entirely so; and does duty in everyrespect. I am in South

Pasadena. Mr. Bristol is north of me. I have the water from nine to twelve, and he has it from twelve to four. The zanjero sends the guard and tells me when to take the water. I stop irrigating at 12 o'clock, and there is no water lost—it flows back to the reservoir. Mr. Bristol opens his main and there is not a drop of water lost. We make 1 inch of water serve over 40 acres.

The CHAIRMAN. Of fruit?

Mr. PECK. We produce everything—all around crops—and we use it for beautifying, for ornamentation around the houses, and we have some just as fine gardens as you have seen in Los Angeles.

Director POWELL. You were going to state what it cost to get the water onto the land.

Mr. PECK. We paid $25,000 for 1,500 acres. That gave us the pipe system and the reservoir. I have put in $14 to $28 per acre for reservoir and system both.

Director POWELL. How did that compare in cost with the new patent method of clay pipe running along the ground?

Mr. PECK. Do you mean the subirrigation principle?

Director POWELL. Yes.

Mr. PECK. Well, it is of no account at all.

Director POWELL. How does the iron-pipe system compare in cost with the clay-pipe system?

Mr. PECK. It can be done for much less.

Director POWELL. State which.

Mr. PECK. The concrete pipe. But it is not a pressure pipe—you have to run your water. One contemplates continuous water on a place, the iron pipe; but if you are 10 miles from the reservoir the water is always there. They have the concrete-pipe system at Etiwanda. There you will sometimes have to ask the question, "How is it you have not plenty of water?" and they will answer, "It is not our week for water; the water is running over on the other side, and we have got to save it." But with us every individual has water right on his place all the time, just as if he owned the whole system.

The CHAIRMAN. The iron-pipe system costs how much per acre?

Mr. PECK. All the way from $10 to $28. It depends on the distance. There is one system that is put in here that has an excellent concrete reservoir; that is at Glendale. That cost $14 an acre, including the reservoir. It is a perfect system—perfect in this respect, that every man has water on his place continuously.

STATEMENT OF J. DE BARTH SHORB, OF SAN GABRIEL, LOS ANGELES COUNTY.

The CHAIRMAN. How long have you resided here?

Mr. SHORB. Since 1867.

The CHAIRMAN. Have you been engaged in farming and cultivating the soil?

Mr. SHORB. I have been engaged all that time in farming—vine culture, tree culture, in fact mixed farming—cultivating grain and everything else.

The CHAIRMAN. What do you say of the success of irrigation in this locality?

Mr. SHORB. It would be very difficult for me in detail to formulate an answer to that question.

The CHAIRMAN. State generally.

Mr. SHORB. It has been everything to our county—it has simply reclaimed large wastes and made of them blooming productive plains.

The CHAIRMAN. What would the average land outside of town be worth if it could not be irrigated?

Mr. SHORB. The land in the San Gabriel proper, about the first mesa beyond Pasadena, and bounded by these low hills, was valueless in 1874, before we carried water onto it. No one would have had it at any price. We bought land at $2.50 an acre. I have placed water on the land and it has sold at $500 an acre, $600 an acre, and $1,500 an acre.

The CHAIRMAN. Were they fancy prices?

Mr. SHORB. Not those in vines and orange trees. Those lands justify the price of $1,000 an acre. Mr. Eaton has well stated about the income from orchards. I made a net income of $1,400 an acre, and for years after that $1,000 an acre.

The CHAIRMAN. What did you cultivate?

Mr. SHORB. Orange trees. So far as grape culture is concerned in that valley, the average yield, according to my books, which I have kept since 1867 until recent years, was 4 tons to the acre, and they sold about $20 a ton until the last few years, making an income of $80 an acre, which should have given a net income, under careful management, of not less than $60 an acre; and if the man did his own work, it could be done at $10. I have done my work at San Gabriel, including cultivation, pruning, plowing, and selling to the buyer at a distance for not quite $10 an acre. Therefore it would gain an income of $60 an acre, which would be in that culture 6 per cent. on $1,000 an acre.

The CHAIRMAN. Does irrigation here increase the grain crops?

Mr. SHORB. We have not practiced irrigation for grain crops; but I have no doubt it would increase.

The CHAIRMAN. How is it as to hay?

Mr. SHORB. We do not use it on those crops. If the grains are irrigated we make a higher crop than in the Eastern States that I am familiar with.

The CHAIRMAN. You irrigate alfalfa?

Mr. SHORB. Alfalfa we irrigate.

The CHAIRMAN. What do you say about the economy of water? What has been your experience about the quantity of water originally used and its economy in this valley?

Mr. SHORB. When I first came here there was a shameful misuse of water. I really thought they were doing more harm than good with the water. When I first came to this country they certainly required ten times as much water as they have now. As Mr. Eaton stated to you that is the result of more thorough cultivation after irrigation, thoroughly wetting the soil, keeping it soft on the top, and instead of the water going away in vapor it goes into the roots of the plants and increases the crops.

The CHAIRMAN. You say they injured the land as much as they did good. Was that by leaving the water on the land, thus producing alkali?

Mr. SHORB. Well, scarcely that—by not disturbing the ground in digging around the roots of plants, and the heat would bake the ground.

The CHAIRMAN. You needed drainage as well as irrigation.

Mr. SHORB. Drainage as much as irrigation. That matter we do not have to consider here, because the fall of the land is so great it naturally *throws off* the water.

The CHAIRMAN. Having improved the land by cultivation, how much have you reduced the amount of water necessary to produce crops?

Mr. SHORB. About one to ten.

The CHAIRMAN. What would be the duty of an inch of water, supposing that to be one-fiftieth part of a cubic foot per second, if it were carried in iron pipes and distributed to the best advantage?

Mr. SHORB. That would depend on the mechanical construction of the land itself. On some land 1 inch of water would be quite sufficient for, I would say, 25 acres of land, and I would say probably as high as Mr. Eaton has stated, 40 acres. That permits the water to run away before it has accomplished its purpose. It is perfectly safe to say, perhaps, that throughout the length and breadth of this country, which I am familiar with, 1 inch of water will serve all the purposes of 20 acres of land, and it should not have any more.

The CHAIRMAN. If the water should be delivered by iron pipes?

Mr. SHORB. Delivered by iron pipes. Of course, that 1 inch could not be used at one time. If irrigation is practiced once a month you have practically 30 inches for that one day.

The CHAIRMAN. What is your judgment about the water supply, if it be stored to the best advantage?

Mr. SHORB. Mr. Patten has given to your committee a good deal of valuable information, and I indorse it. I believe there is enough water falls upon these mountains, if it were stored in reservoirs and saved, to irrigate every acre of land between the mountains and the ocean—more than enough. I, for one, am not so afraid of these rapid descending cañons as I once was.

There is one other point. I think there is very nearly as good a reservoir site at Los Angeles, this town—as good as Bear Valley is.

STATEMENT OF FRED EATON, OF LOS ANGELES.

The CHAIRMAN. What is your profession?

Mr. EATON. Civil engineer.

The CHAIRMAN. Have you been engaged in your business in this vicinity?

Mr. EATON. Yes.

The CHAIRMAN. To what extent are you familiar with the irrigation of this valley and the sources of water supply?

Mr. EATON. I have been connected with almost all the irrigation works of this valley for the last ten years in the capacity of engineer, and I have examined all the works in this county.

The CHAIRMAN. Have you anything to say that would be of interest to the committee?

Mr. EATON. I do not know, except what has been stated here in regard to the benefits of irrigation in this particular section and the possibilities of increasing our present facilities for irrigation. I think that the present streams are developed very nearly to their fullest extent, that is, by the ditch and pipe systems which we have introduced, and in order to increase our irrigation facilities we have from now on to resort to storage. The duty of these streams would be extended by extending the present ditches by pipe systems. Experience has taught us that by economizing the water it is not only the water that we save in seepage alone, but the distribution. The convenience that these pipe systems offer in the distribution of water is a great economizer. We

find that we can get along with a half or third the water that we get in running it around in ditches.

The CHAIRMAN. And serve the land as well?

Mr. EATON. I remember one gentleman thought that the San Gabriel was being used up by irrigating 2,000 acres. But it has been used since for irrigating 12,000 acres.

The CHAIRMAN. And it can be increased by the pipe system?

Mr. EATON. Yes.

The CHAIRMAN. What would be the duty of one-fiftieth of a cubic foot per second throughout this valley under the pipe system?

Mr. EATON. For all kinds of crops, 1 inch to 10 acres; that is, for vegetables and all kinds of crops. Of course, it depends altogether on the character of the soil. A soil that is well subdrained, that is composed of gravel, will require much less water. I remember Major Powell has explained that. This subsoil of gravel is a natural drain, and for that reason water will go a great deal farther on that kind of land than it will on an impervious subsoil. Then it depends on the locality. Some localities within 20 miles from here will require double the water that others do. Taking the average in this valley, with 10 inches you can irrigate all kinds of crops, orange trees, and all kinds of vegetables.

The CHAIRMAN. What is the expense per acre for the pipe service?

Mr. EATON. Of course that depends on the conditions. I estimated for one system not long ago to supply 10-acre tracts. Every tract had a frontage on the street, and the pipe was to run down the street. That was at a cost of $15 per acre. I also made an estimate on a 2,000-acre tract, and that figured out the same way.

The CHAIRMAN. Fifteen dollars an acre?

Mr. EATON. Yes. I have built works where it was $50 an acre. Where the streets are closer together they require more pipes. The cement pipes I do not think are cheaper than the pressure pipes, because it requires a good many more of them, and they are not so convenient as the pressure pipes.

The CHAIRMAN. What thickness of iron pipes do you use in this pressure system?

Mr. EATON. We generally use 16 iron. It is practically the sixteenth of an inch thick. A 4-inch pipe is more difficult to make than a 16-inch. We put asphaltum on, but it is impossible to keep it from being knocked off in spots, and those spots rust there. We can not inspect them closely enough to get at them all and paint them over. In ordinary soil, where there is no alkali, it will wear fifteen or sixteen years. I put in pipes fifteen years ago that are doing service now. I guess I put in pipes for you twelve or fifteen years ago and lighter iron than that—18 iron. The Pasadena pipes were 11 inches with 18 iron. That system was put in in 1873, and served up to this year.

We have not many storage facilities up in the mountains. They are confined practically to the foot-hills and the valleys. We have to bring our water down and make our reservoirs in the valley. In Bear Valley the reservoir will contain 60,000,000,000 cubic feet when it is fully developed, and I am told there are a number of similar ones up there; but the cañons are too precipitous.

STATEMENT OF M. A. KNAPP, CIVIL ENGINEER, OF OAKLAND.

Allow me to lay before your committee a plan for the utilization of *the flood* and winter flows of Owens River in irrigating the land of *Antelope* Valley, in Kern and Inyo Counties, Cal.

The outline of the plan is as follows:

A canal might be run from near Big Pine, on Owens River, south, past the west side of Owens Lake, passing over a low divide about 9 miles south of the lake, and flowing from there in a natural channel most of the way to Antelope Valley. About midway in this channel is Volcano Valley, which is a splendid reservoir site. In fact the lava flows at the lower end seem to have already dammed it sufficiently, so that an outlet tunnel rather than an additional dam would be necessary.

From the entrance to Antelope Valley a high-level canal could be run around the west side and subsidiary ditches would lead the water by easy slopes over the whole of this extensive tract of fertile but at present dry and almost desolate country.

Owens River is a good-sized stream, fed from the springs and snows of the Sierra Nevada Mountains. It flows south throughout the whole length of Owens Valley and empties into Owens Lake. This extensive but shallow alkali lake has no outlet, and the whole flow of the river is evaporated from its surface.

The principal streams flowing into the river are Bishop, Big Pine, Fish Spring, Independence, Lone Pine, and Cottonwood Creeks, all having their sources in the high Sierras to the west. The average flow of the river is about 60 feet wide and 5 feet deep. Such a stream, flowing at a velocity of 1½ miles per hour, carries about 20,000,000,000 cubic feet of water per year. This corresponds approximately to the amount evaporated from the lake, as calculated by the United States Weather Bureau from the report of the Signal Service station at Keeler, which amount was in 1887 100 inches, or about an average of 8 feet a year. According to this calculation there is evaporated on the 70,000 acres of lake surface 24,000,000,000 cubic feet of water per year.

This amount of water would cover 70,000 multiplied by 4, or 280,000 acres 2 feet deep, and as 20 inches of water applied gradually is sufficient for ordinary irrigation (at least, after the land has been watered several years), we may say that enough water flows into Owens Lake to irrigate 300,000 acres of land.

There are now irrigated in the valley about 30,000 acres. The taking of this amount of water from the stream has caused the shores of the lake to recede somewhat; but 70,000 acres is not far from the correct area. By canals proposed and those in process of construction in the valley, about 130,000 acres will be or may be irrigated beyond those already brought under cultivation. The completion of all these canals, however, would still leave flowing in the river enough water to irrigate 140,000 acres.

Let us consider another aspect of the question of the surplus water supply in Owens Valley. The irrigating months, under the climatic conditions which prevail there, are April, May, June, July, and August; and if thorough irrigation is practiced it must be carried on steadily throughout these months. The flood months are June and July, and during them the melting snows of the Sierras fill the stream until it carries six to eight times its ordinary volume. Of this flood not over one-third will ever be used to irrigate Owens Valley, as the amount of land reached by ditches will be only that amount irrigable by the ordinary flow during the months of April, May, and August, or very little more, at most.

During the rainy months of December, January, and February, the river is raised somewhat, but not to a flood height.

When all the available land in Owens Valley is irrigated there will still be running to waste in the lake almost the whole flow of the river

during the months of September, October, November, December, January, February, and March—seven, or let us say six, months' flow. There will also be wasted two-thirds of the flood in June and July. In all, about five-eighths of the total flow of the river will be evaporated in Owens Lake. If it were possible to store a portion of this flow in extensive reservoirs at the headwaters of the river and its branches more of the valley might be irrigated. This, however, is impracticable on any large scale. The water-shed of the Sierras toward Owens River is extremely abrupt, rising 5,000 to 8,000 feet in two or three miles, and the only available reservoir sites are small valleys situated far up in the range, which drain from but small catchment areas.

One more point regarding the water supply is this: Owens Valley is a long narrow basin between two mountain ranges, and all water soaked up by the soil in irrigation seeps eventually to the river. If all the water were taken out high up in the valley the seepage from the lands irrigated there would soon form a stream amply sufficient to fill the small canals from the lower third of the river.

This condition would be more noticeable after a few years of extensive irrigation than at first.

To sum up, then, there is enough water flowing in Owens River to irrigate 300,000 acres of land. Owing to peculiar conditions of flow and usage of water, it is almost impossible that more than one-half this amount, or 150,000 acres, should ever be irrigated in Owens Valley, and highly improbable that it will be profitable to irrigate more than 125,000 acres. This leaves available for watering Antelope Valley about seven-twelfths of the total water supply, or enough to irrigate about 175,000 acres.

Antelope or Salt Wells Valley is situated about 50 miles south of Owens Lake. It contains about 475 square miles or 300,000 acres of valley land, not over two sections or 1,280 acres of which have been located. Fully 200,000 acres of this can be reached and covered with water by a canal entering at the north end, near Nine Mile Cañon Station.

The lowest point of the valley is on the east side, where a small salt marsh and a well of salt-water are found, which give the name found on Wheeler's map of "Salt Wells Valley."

The land slopes from all sides to this point at an average grade of 25 to 50 feet per mile. The dotted red line on the map accompanying this report is an approximate level around the valley from the mouth of the cañon at the north.

The land is excellent. The brush in places is from 5 to 6 feet high. Sand grass grew thickly upon it at one time, but has been fed off till the seed was exhausted. At present a few cattle range in the valley, and a few wild horses are found there.

The only good water in the valley is found at the mouth of "Nine Mile Cañon," at "Indian Wells," at "Cayote Holes," and at a well in the low eastern portion, where an abundance of good water is found about 30 feet below the surface of the earth. At none of these places does the supply amount to a miners' inch at the surface.

The main road south through the valley passes down the west side at the foot of the Sierras, through "Red Rock Cañon," to Mojave, 25 miles farther on, the junction of the Atlantic and Pacific Railroad with the Southern Pacific Railroad. Wagon roads from "Cayote Holes" to Darwin, Panamint, and "Searle's Borax Works" cross the even slope of the valley straight as arrows until they turn into the hills at the *opposite* side.

Back of "Cayote Holes" is Walker's Pass across the Sierra Nevada Mountains, one of the best passes over these mountains, and the only one between Tehachapi, on the south, and Mono Pass, 200 miles north of the valley under consideration.

At the southeast corner of the valley a break in a low range of hills opens to the low plains in which "Searle's Borax Works" are located.

Here the climate and soil are identical with those of Antelope Valley, but considerable water is obtained from springs and artesian wells, and at the Borax Works some 50 acres are under a high state of cultivation. In the orchard there are some thirty fine orange trees, which bear full crops of excellent fruit, besides many other more hardy species of fruit trees. From a 40-acre plat of alfalfa they cut a crop of hay every month in the year, an impossibility except on very rich and productive soil.

The climate of Antelope Valley is the same as that of all the interior of southern California. The little rain it receives is mostly from summer thunder-showers. In the winter the air is cool and strong winds blow from the south. In the middle of summer the temperature is no higher than that of San Joaquin Valley, ranging sometimes to 110° in the shade at meridian. The nights are, however, usually cool and pleasant, even more so than in the valleys west of the Sierras.

The summer heat of these so-called desert valleys has been maligned and called by some insufferable and deadly. The danger of travel here, however, is due entirely to another cause. An exceptionally clear atmosphere causes distances to appear to those unaccustomed to the country to be not more than one-third their real amount, and with an insufficient supply of water even for the trip contemplated travelers are often tortured with thirst before reaching water. Such carelessness has cost many a prospector his life in the arid sections of this country, where now, on account of the changes wrought by the hand of man, travel even on foot is comparatively easy and pleasant.

With water the heat of the sun here would be an advantage in all agricultural pursuits in the early and rapid maturing of all semi-tropical fruits, where now it is a drawback, on account of the total absence of water.

Having estimated the amount of good land available in Antelope Valley and the water supply in Owens River, it remains to consider the canal that would be required to carry the flood and winter flows of that stream to the land to be irrigated in this valley. The only reliable data to be had at present on this subject are of the section directly south of Owens Lake, and are obtained from the surveys of the Carson and Colorado Railroad extension, made in the year 1888.

Of the grade of Owens River and the slope of the land west of it nothing is definitely known; the general character of the country can be easily seen, but only a preliminary survey, or at least a careful reconnaissance, can be relied on to determine even to an approximation the course and length of the canal necessary.

The railroad levels show that the divide, which has its highest point about three-quarters of a mile north of "Hawai" Station, and about 9 miles south of Owens Lake, rises about 175 feet above the level of the lake. Since a cut could be made here, we may calculate upon a height of 160 feet. Let us suppose that a canal 90 miles long would have to be run from this point with a grade of 8 inches per mile to reach Owens River. This would make a height at the upper end of 160+8-12ths of 90, or 220 feet above Owens Lake.

The grade of Owens River is not known. It follows a rather tortu-

ous course, and has a few rapids. Probably 4 feet to the mile is not too high an estimate of its fall; 6 feet per mile is probably about correct. A canal as proposed, running 90 miles north from Hawai, would tap it 60 miles up its winding course, and sixty times four, or 240 feet above Owens Lake, if the above estimate of the river's grade is correct.

Taking the water from a point 60 miles above the lake, near Big Pine, it could be carried on easy ground for about 25 miles. It would then be just north of the Alabama Hills, a low range lying parallel to the Sierras and close to their base. Whether the canal would pass behind or below them, only a level will show. In any case, only about 10 miles of rough work need be done.

To the west of the lake the ground would be fairly easy, and from Olaucha to the entrance to the cañon, 4 miles north of Hawai, but little heavy cutting need be done. This point is 165 feet above the lake, and the ground falls, and then rises again 25 feet in going towards Hawai Meadows. The work along here might be quite difficult, but if extremely so, the whole narrow channel might be flooded.

From Hawai south to Volcano Valley the grade is quite heavy. No rock cutting would be necessary, but to keep the water from washing the loose soil it would have to be guided in its course part of the distance.

In Volcano Valley the line of wagon road on the west side (shown on the map), is about on a level. The ground to the east falls about 150 feet to the centre of the valley, two miles from the road. To the west of the volcano, at the southern end of the valley, the ground is about on the level of the road; and to the east it appears to be about the same height for most of the distance across to the hills on the opposite side. If it does continue across at this level, which a reconnaissance will show or disprove, no dam will be required and an outlet tunnel can be run through the narrowest part of the divide to the head of the cañon below.

If however a dam should be necessary, it need be but a comparatively small one to flood from 5 to 10 square miles to a depth of from 50 to 75 feet—a reservoir sufficient to store one-third the yearly flow of Owens River, at least.

Immediately below Volcano Valley is Little Lake, which could be used as a secondary reservoir. Below the lake a good channel could be secured with but little cutting, to the entrance to Antelope Valley.

In our consideration of water supply we have found that water enough for 175,000 acres is available in Owens Valley. Let us allow a very liberal margin for seepage and other losses, and say that only about one-half of this amount can be brought to Antelope Valley. This would make productive nearly 90,000 acres of land. This at a value of $100 an acre, which is not an exorbitant price for such fertile land when thoroughly irrigated, would make a valuation of $9,000,000.

I do not attempt to make even a rough estimate of the cost of construction of such a canal; but since 70 out of the 100 miles would be in easy ground, the rest must be extravagantly expensive to bring the total cost so high as not to leave a very large margin out of the $9,000,000 increase in value of what is now worthless land.

It is almost unnecessary for me to enlarge upon the splendid future of Antelope Valley should the proposed scheme be carried out. Two railroad surveys have crossed the valley; the Carson and Colorado from north to south, and the Utah Southern from east to west through Walker's Pass. It is probable that both these roads will be built in the near future. Owens Valley must have an outlet south, and Utah must some *time continue* her road from Frisco to California. The Sierra Nevada

Mountains to the west would yield from inexhaustible forests immense quantities of wood and timber for the railroads and the industries of the valley. To the north and east lies a splendid mining country, containing the Darwin, Paniment, Coso, Slate Range, Lyons, Death Valley, Armagosa, and other mining districts, which only wait railroad transportation to ship large quantities of rich silver and lead ores to some place where wood and fuel are to be had for smelting purposes. These, together with cheap water-power from the falls in the cañon, would be had at Antelope Valley.

I have said that $100 would not be too high a valuation for an acre of irrigated land in this valley were the proposed canal completed; but when we consider that the valley has as fine a climate as Los Angeles; that the soil is as good as any in the State; that a large and rich mining country would be tributary to it, and that the crossing of two railroads in it would give outlets north, south, east, and west, it does not seem improbable that, considering all the varied interests which would concentrate there, the value of property in a few years would be fully $200 per acre of land actually irrigated, and a thriving population of twenty to thirty thousand people would be supported where now but a few head of cattle can be ranged.

In conclusion, allow me to give the sources of the information furnished in this report:

Mr. L. F. J. Wrinkle, surveyor on the Comstock mines in Virginia City, made an examination of the proposed route of the canal, and collected data regarding Owens Valley and River. Being pressed for time, and knowing that I was well acquainted with the country south of the lake and with Owens Valley, he requested me to use his notes, and from them and my own knowledge to make a report on the plan to the Senate Committee on Irrigation. Almost all the information regarding Owens Valley and River I quote from his notes; that of the country south is of my own knowledge or from reliable information obtained while employed as surveyor of the Carson and Colorado Railroad extension to Mojave.

It may, of course, be the character of the country on the proposed canal route, and perhaps the configurations of Volcano Valley are so different from what is supposed in this report that the canal would be utterly impracticable. No facts are at hand, however, which prove this to be the case.

Probably there is no place in the country where so large a body of fertile, but at present dry and desolate, land is to be found, with water enough going to waste 50 miles away and 1,000 feet above it to irrigate 100,000 acres of it, which land belongs entirely to the Government, and might be reserved from sale until, with a good water right, it could be sold at a price to pay the cost of the canal.

I therefore take the liberty of laying this proposition before your committee, hoping that while you are having surveys made in California for Government canals and storage reservoirs, you will cause either a survey or a reconnaissance to be made in Owens and Antelope Valleys, and not dismiss the plan offered as visionary and impossible until you may have proved it so by reliable data.

Mr. Oliver, formerly engineer of the Carson and Colorado Railroad is authority for the statement that the average grade of Owens River from Bishop Creek to the lake is 7 feet per mile, and it is generally understood that near Bishop the grade is about 10 feet per mile. Mr. Wrinkle informs me that he leveled up the river for 4 miles from the lake and found the average grade to be 5 feet per mile for that distance. This is *probably the lowest* grade on the whole river.

The average velocity of flow in a stream such as Owens River, flowing 300 feet wide and 6 feet deep (with a fall of 5.28 feet per mile,) is (by "Kutter's" formula) 3.2 feet per second, or over 2 miles per hour, and the yearly flow 30,000,000,000 cubic feet, instead of 20,000,000,000, as I have estimated in this report.

The amount of evaporation from the lake is calculated as from a quiet surface, but the waves on the lake increase the actual surface and the evaporation is probably considerably in excess of 8 feet (the amount given by the United States Weather Bureau), and the total evaporation is probably 30,000,000,000 cubic feet.

The proposed canal would be expected to carry something over the average flow of the river; or, an amount equal to that which would be carried by all the other canals in Owens Valley. A canal 60 feet wide and 5 feet deep, with a fall of 1 foot to the mile, would carry (by Kutter's formula) the full flow of Owens River, or 30,000,000,000 cubic feet per year. The amount delivered at the lower end would depend on the length of the canal, the character of the soil in the country passed through, and the care exercised in the construction. The highest loss on record is 40 per cent. of total flow. The loss in the proposed canal would decrease considerably after several years' use of the water, as the fine silt carried by the stream would fill up the loose soil on the banks and bottom of the canal. This has been found to be the case in India, where very porous and poorly constructed dams have, after long use, become perfectly tight from the silt carried into them by the water.

The objection has been raised by some to whom this scheme has been proposed that the water rights of Owens River are all appropriated. This is true of the ordinary flow in the irrigating months, but the winter flow will never be used in Owens Valley, as the rain-fall during this season is fairly heavy. The flood flows will always be too large to be handled by the canals in the valley. Should the proposed canal be built it is probable that it would be profitable to take two-thirds of the flow of the river to the land of Antelope Valley, which is not only more fertile than most of that in Owens Valley, but also much nearer the markets of the country and the great overland roads.

Adjourned.

ON TRAIN, NEAR SAN BERNARDINO, CAL.,
September 2, 1889.

The committee met pursuant to the call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF W. C. BUTLER, OF REDLANDS, SAN BERNARDINO COUNTY.

The CHAIRMAN. What is your occupation?

Mr. BUTLER. I am an engineer.

The CHAIRMAN. What engineering work have you been engaged in in this county?

Mr. BUTLER. I have been connected with the Bear Valley reservoir, principally. I have here a map which shows what it is, giving the elevation of the dam, etc. [Hands in the map.]

The CHAIRMAN. Does it show the width at the base?

Mr. BUTLER. Yes; it shows the horizontal projection and the area at the present time covered by it.

The CHAIRMAN. Are all these areas represented on this map by figures?

Mr. BUTLER. Yes.

The CHAIRMAN. Upon what basis did you estimate the extent of waste weir? Can all the water run out at flood time without getting to the top of the dam?

Mr. BUTLER. Yes.

The CHAIRMAN. What provision have you made against flooding.

Mr. BUTLER. The work is not yet completed but we are working at it.

The CHAIRMAN. How much of a water-shed have you there?

Mr. BUTLER. Sixty miles. The present elevation of the waste-weir is 10 feet below the top of the dam.

The CHAIRMAN. In those waste-weirs do you not have a temporary gate so that you can keep in a part of the water?

Mr. BUTLER. Yes.

The CHAIRMAN. I wish to say to you that if any calamity should happen to this dam it would injure the cause of irrigation in the United States very greatly.

Mr. BUTLER. There is no doubt of that.

The CHAIRMAN. What is the width of it?

Mr. BUTLER. The thickness of the foundation is about 20 feet through at the bottom.

The CHAIRMAN. What is the height of the dam?

Mr. BUTLER. Fifty feet. You may recollect that this dam is not a gravity dam, but acts as an arch.

The CHAIRMAN. Explain that.

Mr. BUTLER. It acts as a curve, or arch, instead of a gravity dam. The radius of the curve is 325 feet. It depends upon its strength—upon the crushing resistance of the material rather than on its resistance to being shoved out. This dam has stood for five years. It is the first dam that has been built on this coast on that principle. It has been under considerable discussion during the past year, and I think the dam is taken by engineers to be a demonstration of the value of this principle. The Sweetwater dam is on this principle, but that is 90 feet high, 40 feet through at the base.

The CHAIRMAN. Do you intend to build that any higher?

Mr. BUTLER. Not on that base.

The CHAIRMAN. Can you not build another one below it?

Mr. BUTLER. It is cheaper to build below.

The CHAIRMAN. Have you commenced the construction of one below?

Mr. BUTLER. No.

The CHAIRMAN. (Showing the witness a map of the sections and cross-sections of the proposed dam.) How far is that from the other dam?

Mr. BUTLER. It is 150 feet below.

The CHAIRMAN. Are you going to fill in between the two?

Mr. BUTLER. No. This plan, if completed, will have a gravity section. That is, it will resist, to a pushing force down the cañon, a coefficient of two; and, in addition to this, it is built as an arch, and ends the same as the present one does.

The CHAIRMAN. Then you will abandon the present one when you get the second one?

Mr. BUTLER. Yes, practically. The present dam has cubical contents of 3,300 yards. The difficulty of completing the new dam so as

to make a perfect bond between the two is so great that it would be cheaper to build the new dam below—starting on a new foundation. These 3,300 cubic yards cut so small a figure in the new dam that it would not be of sufficient value to include it. The cubical contents of this 80-foot dam on the side would be perhaps 25,000 cubic yards.

The CHAIRMAN. What other engineering have you done?

Mr. BUTLER. That is my principal work. Do not understand me as saying that I was the engineer of that work. I was simply an assistant. Mr. F. E. Brown was the engineer that planned and built the work, and I acted as his assistant.

STATEMENT OF G. W. BEATTIE, OF SAN BERNARDINO COUNTY.

The CHAIRMAN. What is your occupation?

Mr. BEATTIE. I am county treasurer, but have had considerable to do with the water-works in the eastern end of the valley.

The CHAIRMAN. What do you say of the duty of water in the eastern end of San Bernardino Valley? How much will an inch of water irrigate?

Mr. BEATTIE. It depends to a great extent upon what we are growing. The orange I put from an inch to 3 acres up to an inch to 6 or 7 acres. Some crops require more than others.

The CHAIRMAN. Will you explain the mode of the distribution of water there? Do you take it up by ditches, pipes, or how?

Mr. BEATTIE. In this settlement we make stone ditches altogether. We have the ditches paved with stone, and the water is let out from the ditch by measuring weirs, and each party gets his pro rata.

The CHAIRMAN. You bring the water to a man's land?

Mr. BEATTIE. Yes.

The CHAIRMAN. How is it brought to the land?

Mr. BEATTIE. Through perforated flumes largely. But a large extent of it was a V-flume, with little slides over the openings to regulate the flow of water.

The CHAIRMAN. Then you do not flood?

Mr. BEATTIE. No; we do no flooding at all, except on alfalfa. Our use for water is largely for fruit growing. An inch of water is good for from 3 to 6 or 7 acres in that part of the country.

The CHAIRMAN. Have you paid any attention to drainage?

Mr. BEATTIE. No.

The CHAIRMAN. What is the difference between the value of land that is irrigated in that valley and land that has no chance to be irrigated?

Mr. BEATTIE. Land that could not be irrigated would not be worth over $25 an acre, while the same land if irrigated would bring from $150 to $200 or $300. It will vary according to the climatic conditions.

The CHAIRMAN. What does it cost, per acre, to irrigate it? What are the factors that fix the value at from $25 to $300 an acre?

Mr. BEATTIE. I hardly know how to answer that question.

The CHAIRMAN. Does the company own the water?

Mr. BEATTIE. The company consists of the people. It is a community company, and the company manages the water strictly for the good of the people. It is not conducted for a profit, but simply to manage the water rights.

The CHAIRMAN. About what does it cost to get things into that condition?

Mr. BEATTIE. The water ditches are a very small part of the valuation of the water rights. I suppose you understand that they are quite distinct.

The CHAIRMAN Take the water right, or anything you please, about how much an acre would it cost?

Mr. BEATTIE. I can not give you an answer to that.

The CHAIRMAN. What success have you with crops on irrigated land?

Mr. BEATTIE. On irrigated land we never have a failure with crops, except in some extraordinary or exceptional case.

The CHAIRMAN. What is an average return from the raisin vine?

Mr. BEATTIE. We do not consider $150 an acre gross to be an excessive amount.

The CHAIRMAN. How much net?

Mr. BEATTIE. One hundred dollars an acre.

The CHAIRMAN. How is it with oranges?

Mr. BEATTIE. We have very little experience on my place with those. We have growing trees that are beginning to bear.

The CHAIRMAN. Have you ever used too much water, or does that affect the crops?

Mr. BEATTIE. It does, because crops will mildew with excessive water, and the excessive use of water is apt to start certain diseases on the trees.

Adjourned.

ON TRAIN AT RIVERSIDE, *September* 2, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan, also Director Powell.

STATEMENT OF CHARLES FRANKISH, OF ONTARIO.

The CHAIRMAN. In what county is Ontario?

Mr. FRANKISK. San Bernardino County.

The CHAIRMAN. What is your occupation?

Mr. FRANKISH. I am manager of the Ontario Land and Improvement Company.

The CHAIRMAN. What do you mean by manager?

Mr. FRANKISH. I have the full management of the company's lands and irrigating systems.

The CHAIRMAN. What is your irrigation system at Ontario?

Mr. FRANKISH. We take the mountain waters and distribute them by pipes through the irrigated lands.

The CHAIRMAN. How by pipes—what kind of pipes do you use?

Mr. FRANKISH. Cement pipes for irrigation, iron pipes for domestic purposes.

The CHAIRMAN. What kind of iron pipes?

Mr. FRANKISH. Wrought-iron and cast-iron; varying in size from 4 to 12 inches, cast-iron; cement pipes, 8 to 48 inches.

The CHAIRMAN. How are the cement pipes constructed?

Mr. FRANKISH. They are molded in lengths of about two feet and laid in sections, joined together by cement.

The CHAIRMAN. Do you lay them on the ground?

Mr. FRANKISH. Yes.

The CHAIRMAN. Of what size are they?

Mr. FRANKISH. From 8 to 48 inches in diameter.

The CHAIRMAN. What does a 48-inch pipe cost per lineal foot?

Mr. FRANKISH. They are 25 cents per lineal foot now.

The CHAIRMAN. What pressure will they stand?

Mr. FRANKISH. They are not supposed to stand over 25 or 30 feet head. We never put over that on them.

The CHAIRMAN. What quantity of water will pass through a 48-inch pipe with 25 feet head, say for a mile, without taking off the friction?

Mr. FRANKISH. If I remember, 3,000 inches, with a grade of one to the hundred.

The CHAIRMAN. What is the cost of a 24-inch pipe per lineal foot?

Mr. FRANKISH. About 50 cents per lineal foot.

The CHAIRMAN. What does a foot pipe cost?

Mr. FRANKISH. Twenty-four cents.

The CHAIRMAN. An 8-inch pipe?

Mr. FRANKISH. Seventeen cents per lineal foot.

The CHAIRMAN. How much land will a miner's inch, or one-fiftieth of a cubic foot, per second irrigate?

Mr. FRANKISH. Ten acres of land. Gravelly loam holds the moisture.

The CHAIRMAN. For what kind of crops will that irrigate 10 acres?

Mr. FRANKISH. The citrous fruits, oranges and lemons.

The CHAIRMAN. How much would it require to raise ordinary farm vegetables?

Mr. FRANKISH. I do not think any more would be required except it would be alfalfa.

The CHAIRMAN. I am not speaking of that; I am speaking of just the ordinary farm vegetables.

Mr. FRANKISH. It would require no more than for oranges.

The CHAIRMAN. Have you an ample supply of water?

Mr. FRANKISH. Not for all our land. We have the longest tunnel in the State; it is 2,900 feet long.

The CHAIRMAN. Running into what mountains?

Mr. FRANKISH. San Antonio Cañon, in the Sierra Madra Mountains.

The CHAIRMAN. Have you by means of that tunnel developed any water?

Mr. FRANKISH. Yes; we have flowing only a limited quantity; 60 or 75 inches at present. We are 400 feet beyond the point where we expected to get water.

The CHAIRMAN. Have you any opportunities there for the storage of water?

Mr. FRANKISH. Yes; four good reservoir sites at San Antonio Cañon, which are owned by the company.

The CHAIRMAN. Does much of the water run to waste in the winter season?

Mr. FRANKISH. Much, except what is used for domestic purposes. Of course the stream in the winter is ten times as great as in the summer season.

The CHAIRMAN. And that is all lost?

Mr. FRANKISH. Yes.

The CHAIRMAN. At what season of the year do you irrigate?

Mr. FRANKISH. From about the 1st of June to about the 1st of October.

The CHAIRMAN. Have you experimented with winter irrigation?

Mr. FRANKISH. Not to any extent. I think one or two individuals have, but I think our rains in the winter are ample. Unless there was

a dry season, I do not think irrigation would benefit our locality, unless it came in a very exceptionally dry season.

The CHAIRMAN. How long has your system been in operation at Ontario, and what was the condition of things there when you commenced operations?

Mr. FRANKISH. The first sod was turned in June, 1883. It was an ordinary desert at that time, producing no crops whatever, and to-day we have an orange grove of three boxes to the tree. We have that this season.

The CHAIRMAN. What is the size of your orange grove?

Mr. FRANKISH. About 2,000 acres.

The CHAIRMAN. Do you raise any other citrous fruits there?

Mr. FRANKISH. Lemons. Lemons do exceedingly well with us. I believe there are probably 125 acres there in lemons.

The CHAIRMAN. Your trees have just commenced to bear?

Mr. FRANKISH. Yes. They bore last year, in some places 2 boxes to the tree, and this season they have fully 3 boxes to the tree. I am speaking of the older growth.

The CHAIRMAN. What was the land worth at Ontario before you commenced.

Mr. FRANKISH. I think the land might have been bought for $1.25 an acre.

The CHAIRMAN. What is it worth now?

Mr. FRANKISH. Our lowest price is $200 an acre. I have sold as high as $400 and $500, choice locations.

The CHAIRMAN. What water did you have to start with.

Mr. FRANKISH. The first measurement of the creek was 365 inches.

The CHAIRMAN. To what extent have you developed that?

Mr. FRANKISH. To a little over 400 inches at the present time. And we have a number of details showing more water, but not actual measurement, such as shafts sunk.

The CHAIRMAN. How many acres have you under your water system?

Mr. FRANKISH. There are about 5,000 acres piped. We have about 9,000 suitable for irrigation.

The CHAIRMAN. Do you expect to extend your pipes to the full 9,000 acres?

Mr. FRANKISH. Yes.

Adjourned.

RIVERSIDE, CAL., *September* 2, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF C. S. EVANS, OF RIVERSIDE.

The CHAIRMAN. How long have you resided in Riverside?

Mr. EVANS. I have resided here fifteen years.

The CHAIRMAN. Were you one of the originators of the scheme?

Mr. EVANS. I am the second originator. I built the second canal, which was originated by Judge North in the first instance.

The CHAIRMAN. What was the then condition of this country which is now covered by orange groves?

Mr. EVANS. It was a barren plain—dry land.

The CHAIRMAN. What was it worth per acre at that time?

Mr. EVANS. I suppose it was worth about the price it was sold for—from $3 to $5 an acre.

The CHAIRMAN. What is it worth per acre now, with water on it?

Mr. EVANS. It is worth, with water attached to the land, from $200 to $300 an acre—dry land, unimproved land, I mean.

The CHAIRMAN. What is it worth when you get oranges on it?

Mr. EVANS. Our orange orchards are selling at from $750 to $2,500 an acre.

The CHAIRMAN. What is the net annual return from orange orchards selling at that price?

Mr. EVANS. They will pay 10 per cent. on the money that is paid for them.

The CHAIRMAN. Then the land is worth the price on which you can pay 10 per cent?

Mr. EVANS. Yes.

The CHAIRMAN. How much land here is under cultivation, under water; how much can be covered by irrigation?

Mr. EVANS. About 12,000 acres.

The CHAIRMAN. What part of that is actually under irrigation?

Mr. EVANS. I am speaking of the area that is under the Riverside Water Company's canal—12,000 acres.

The CHAIRMAN. How much is under other water-works?

Mr. EVANS. There is about the same amount.

The CHAIRMAN. Making about 24,000 acres in all?

Mr. EVANS. Yes.

The CHAIRMAN. How much of the 24,000 acres is actually under cultivation?

Mr. EVANS. Perhaps more than 12,000 outside of this company; that is, the Gage system—what is called the Vivienda.

The CHAIRMAN. Then that would make more than 24,000 acres?

Mr. EVANS. Perhaps from 25,000 to 30,000 acres.

The CHAIRMAN. Of that land which is covered by these systems, what amount is actually under cultivation?

Mr. EVANS. There is actually under cultivation under the old canals—that is, the Riverside Water Company's canals—6,300 acres.

The CHAIRMAN. How much under the new system?

Mr. EVANS. About 1,500 acres. There is none under cultivation in the Vivienda. That comprises the amount under cultivation.

The CHAIRMAN. Have you a water supply for the 25,000 acres, so that it may be ultimately put under cultivation?

Mr. EVANS. I think we have, without any question.

The CHAIRMAN. Have you made any attempts to increase your supply of water beyond what naturally flows in the streams.

Mr. EVANS. Yes. We have built in the last two years flumes and aqueducts, and have cemented a portion of the canals. We have extended our upper canal system where it originally headed in the river from the tributary, Warm Creek, so that we get water through a canal that is partly cemented, partly in the earth, and from a long flume or tunnel from which it is taken into the old canal about a mile and a half above our town.

The CHAIRMAN. Do you find that it is of material value in saving water to cement your ditches.

Mr. EVANS. Yes, a very great saving of water. It saves in evaporation and seepage very considerably.

The CHAIRMAN. Is that an expensive system?

Mr. EVANS. Yes, somewhat expensive.

The CHAIRMAN. What is the size of your ditch?

Mr. EVANS. Mr. Newman, the engineer, can give you that.

The CHAIRMAN. What system have you for distributing water? Do you allow it to run into the ditches, or do you have it piped?

Mr. EVANS. We have both systems. We are extending the pipe system. That is not the irrigation system. We have a system of iron pipes, for domestic purposes, in the artesian belt through our town and throughout the valley seven miles below.

The CHAIRMAN. For irrigation purposes you have now commenced to use pipes. What kind did you use before?

Mr. EVANS. Concrete cement pipes.

The CHAIRMAN. Have you estimated per acre the cost of the pipe system?

Mr. EVANS. Yes.

The CHAIRMAN. How much is it?

Mr. EVANS. The engineer can give you that better than I can.

The CHAIRMAN. Can you tell something with regard to the productiveness of the soil for oranges, etc.? Can you make a statement as to the result of irrigation?

Mr. EVANS. We have certain areas in grapes and oranges. Those are our staple productions. We have experimented from fifteen years ago with everything until we have gotten down to a standard- raisin grapes, oranges, and lemons. Our vineyards are from four to six years old; a fair production, I think, will average $100 per acre.

The CHAIRMAN. One hundred dollars an acre gross or net?

Mr. EVANS. That is the gross return. They net $75 per acre per annum.

The CHAIRMAN. What do you find with regard to oranges?

Mr. EVANS. They are paying according to their condition and age from $300 to $1,250 per acre. Our best oranges are paying from $1,000 to $1,250 per acre, and younger oranges from $300 to $500 per acre.

The CHAIRMAN. Are those the net or gross returns?

Mr. EVANS. Those are the gross returns.

The CHAIRMAN. What would they be net?

Mr. EVANS. Take off $50 an acre, and that would represent the cost of cultivation.

The CHAIRMAN. That would be $1,100 net?

Mr. EVANS. Yes. You can say $1,000 for the oldest oranges.

The CHAIRMAN. How much would it be for trees four years old?

Mr. EVANS. That would depend entirely upon the kind of trees they were. If budding trees, they would commence to bear at three years old, and would get a pretty fair paying crop; if seedlings, they would bear from ten to twelve years from the seed.

Senator REAGAN. What is the distance from the source of your water to the main canal? What distance do you have to bring your water?

Mr. EVANS. We have two main canals; one of them 12, and the other under Mr. Newman, which is from 4 to 5 miles.

Senator REAGAN. Do you raise small grain in this valley?

Mr. EVANS. Yes, we do; but it is on dry land. We do not raise much by irrigation.

Senator REAGAN. What kind of crops do you raise on the dry land?

Mr. EVANS. Barley is the principal crop in this country.

Senator REAGAN. Can you state what is the profit on unirrigated land that is in barley?

Mr. EVANS. I do not know that I can give you that as well as other parties. Well, we will probably get two or three crops out of five.

Senator REAGAN. Do you raise wheat?

Mr. EVANS. We do; but it is not a valuable crop with us. It is subject to the rust. We raise alfalfa to good advantage on irrigated land.

Senator REAGAN. How many tons of alfalfa to the acre do you expect to realize on irrigated land?

Mr. EVANS. A crop of alfalfa, attended to as it ought to be, will produce from 6 to 8 tons per acre a year.

STATEMENT OF G. O. NEWMAN, OF RIVERSIDE.

The CHAIRMAN. How long have you resided at Riverside?

Mr. NEWMAN. Since January, 1875.

The CHAIRMAN. What is your profession?

Mr. NEWMAN. Civil engineer.

The CHAIRMAN. Are you acquainted with the Riverside irrigation works?

Mr. NEWMAN. I am the engineer of the Riverside Water Company.

The CHAIRMAN. Make a statement in your own way of the sources of your water supply, how much water you have, the amount of land you cover, and the expenses, etc.

Mr. NEWMAN. Our main supply is from the Santa Ana River, and this summer we have sunk some artesian wells. We have also put in some underground drains. Altogether we take in about 3,200 inches of water.

The CHAIRMAN. How many cubic feet per second would that be?

Mr. NEWMAN. That is 40 cubic feet per second, and of that we sell but 2,000 inches; the balance is lost by seepage and evaporation in the ditches. We have about 32 miles of main canal and 150 miles of distributing ditches.

The CHAIRMAN. You have made some efforts to diminish the amount of evaporation and seepage?

Mr. NEWMAN. Yes; by cementing the canal.

The CHAIRMAN. State how much that cost, and how it affected the evaporation and seepage.

Mr. NEWMAN. Where we cement the canal we lay 6 inches of stone and rubble masonry, and plaster that over with cement. That cost $2.75 a lineal foot.

The CHAIRMAN. That is along your canal?

Mr. NEWMAN. Yes.

The CHAIRMAN. How large is your canal?

Mr. NEWMAN. Eight feet wide at the bottom and four feet deep.

The CHAIRMAN. How much of your canal have you improved in that way?

Mr. NEWMAN. We have not more than about a half-mile altogether, except the tunnel. We have a tunnel 3,300 feet long, and that is all cemented.

The CHAIRMAN. Have you cemented enough to estimate the difference between letting it run in the ditch without improvement and in the cemented work? Can you state what the difference between the two is?

Mr. NEWMAN. No, I cannot say that. We have run in from where we take the water out of Warm Creek 1,400 feet of cemented canal;

after that 7,000 feet of flume, and 3,300 feet of tunnel cemented. There is a five-inch stream, and when it leaves the tunnel it will sink 150 feet.

The CHAIRMAN. What quantity will it discharge at the lower end?

Mr. NEWMAN. About 3 inches of it—about three-fifths will run through. But that will sink entirely within 150 feet of the tunnel.

The CHAIRMAN. If you had the same kind of cement work all along how far would it run?

Mr. NEWMAN. It ought to run 3 miles before it all could run out.

The CHAIRMAN. In distributing the water do you do it in ditches or by pipes?

Mr. NEWMAN. Mostly in ditches. We have lately commenced to put in cement pipes in the lateral ditches.

The CHAIRMAN. Have you experimented enough with cement pipes to know what would be the difference?

Mr. NEWMAN. Yes.

The CHAIRMAN. What is the difference between the duty of water in cement pipes and water in ditches?

Mr. NEWMAN. In ditches we lose at least 15 per cent. Still that varies. If a ditch is used when it is dry we will lose more during the first days of irrigation. With the pipe lines the loss cannot be more than 5 per cent.

The CHAIRMAN. What is the duty of water with your ditches?

Mr. NEWMAN. Do you mean how many inches to the acre?

The CHAIRMAN. How much land will an inch of water serve?

Mr. NEWMAN. One inch to three acres.

The CHAIRMAN. Have you estimated what would be the duty of water if you had pipes put down to the best advantage?

Mr. NEWMAN. Yes. Well, I can not say that I have estimated that fully, because we have not had in enough pipes to draw from.

The CHAIRMAN. The engineer at Ontario estimates the duty of water to be an inch to 10 acres.

Mr. NEWMAN. When the trees get to bearing?

The CHAIRMAN. I will ask you this question. Do you know the character of soil that they have at Ontario, and whether it is different from this soil here?

Mr. NEWMAN The Ontario soil is very sandy.

The CHAIRMAN. Which would require the most water, the Ontario soil or this here?

Mr. NEWMAN. I should judge that the Ontario soil would require the most.

The CHAIRMAN. They say they serve 10 acres with an inch of water.

Mr. NEWMAN. But they can not make a success of raising oranges. They can make the trees grow, but they can not get the fruit without giving the trees the water.

The CHAIRMAN. Suppose the water were carried in pipes to the tree, or where you wanted to use it?

Mr. NEWMAN. It would pretty nearly come to that.

The CHAIRMAN. One inch to 5 acres?

Mr. NEWMAN. Yes, 1 inch to 5 acres. And I think that is the limit.

Mr. HINTON. The difference then would be 3 acres in ditches and 5 in pipes?

Mr. NEWMAN. Yes.

The CHAIRMAN. Do you agree as to the amount of land that is covered by these streams, that is to say, that it is 25,000 acres?

Mr. NEWMAN. Yes; about that.

The CHAIRMAN. Is there a water supply for the whole of that?

Mr. NEWMAN. That I could not say; this summer it has shown that the artesian basin is rather low.

The CHAIRMAN. Is this the usual season or is it dryer than usual?

Mr. NEWMAN. It is rather a dry season, but it is not one of the dryest.

The CHAIRMAN. You have not tried to store water?

Mr. NEWMAN. No, not here.

The CHAIRMAN. Nor have you examined to see whether there are any opportunities for storing water?

Mr. NEWMAN. Right here there is not a good opportunity; we have Bear Valley up above. That is an excellent place.

The CHAIRMAN. That is used at other places; the water does not come here.

Mr. NEWMAN. Some water from there got down here this summer. They had to let it out and we got the benefit of it.

The CHAIRMAN. What does it cost per acre to irrigate by the pipe system; to use cement pipes? What does it cost to provide that system?

Mr. NEWMAN. We have very little of the cement pipe, having just commenced this summer, and it would be difficult to tell. We have used open ditches here altogether.

Mr. HINTON. What is the cost per acre for the ditches?

Mr. NEWMAN. That varies considerable; some persons irrigate so much more than others. Here is the percentage of water used in different months: In January, 2 per cent; in February, 1 per cent; in March, 2 per cent; April, 9 per cent; May, 15 per cent; June, 18 per cent; July, 16 per cent; August, 15 per cent; September, 12 per cent; October, 7 per cent; November, 4 per cent; and December, 1 per cent.

The CHAIRMAN. You spoke of selling the water to the people. How is the water owned, and how do the people acquire it?

Mr. NEWMAN. The oldest settlers own the water, and they just pay enough to keep up the running expenses of the company.

The CHAIRMAN. And the water is connected with the land?

Mr. NEWMAN. The water is connected with the land.

The CHAIRMAN. And the charge is made according to the amount of water they use, sufficient only to get a living for keeping up the company?

Mr. NEWMAN. Yes.

The CHAIRMAN. And the settlers elect their officers and carry this out?

Mr. NEWMAN. Yes.

Mr. EVANS. Each acre of land under these canals is provided with water stock, and the owner of the land has the water stock. There are three shares of water stock to each acre of land, because some sections are laid off into half-acre lots. The half acre represents a share of stock, and the owners of the land throughout the whole valley are the stock owners. There are two companies, and the settlers and the different companies are stockholders in the Riverside Company.

The CHAIRMAN. And they vote in proportion to the amount of stock they own.

Mr. EVANS. Yes. One share of stock is entitled to a vote.

The CHAIRMAN. And they assess themselves to say how much is to be charged to the consumer?

Mr. EVANS. The rate is fixed by the authorities, the municipal or county government. Here we have city trustees to fix the rate according to law They fix it at the dictation or suggestion of the water company.

The CHAIRMAN. They rate it at the amount that they require for their own purposes in order to declare dividends?

Mr. EVANS. Only to cover expenses. The rate until this last year for several years back was 7½ cents per inch for twenty-four hours. This year the rate was advanced to 10 cents an inch.

The CHAIRMAN. Why did you advance it?

Mr. EVANS. Because we increased the expense by making improvements on our water-works.

STATEMENT OF JOSEPH JARVIS, OF RIVERSIDE.

The CHAIRMAN. How long have you resided in Riverside?

Mr. JARVIS. Between twelve and thirteen years.

The CHAIRMAN. What is your occupation?

Mr. JARVIS, Fruit growing, principally.

The CHAIRMAN. What do you say as to the duty of water?

Mr. JARVIS. In the midsummer months it is 1 inch to 3 acres; but during the winter months a good deal less water is required. But during the active season, when we require the water, the duty is 1 inch to 3 acres, whether delivered through the ditch or the pipe line.

The CHAIRMAN. Is there a surplus of water in the winter season in the river that you could take out and prevent from going to waste?

Mr. JARVIS. Yes, for several months in the winter season there is a loss of water.

The CHAIRMAN. You make no effort to store or save that water?

Mr. JARVIS. We have no storage reservoirs provided by our system here.

The CHAIRMAN. If you had reservoirs would there be surplus water that you could store?

Mr. JARVIS. Yes, during the winter months there would be.

The CHAIRMAN. What system of irrigation do you use on your place? Have you ditches, or have you the pipe service?

Mr. JARVIS. There are ditches and a flume upon my place.

The CHAIRMAN. Is a flume better than a ditch to save evaporation and seepage?

Mr. JARVIS. It saves the seepage nearly altogether, and narrows the exposed surface very much, and thus saves evaporation. If the asphalt be properly placed in the ditch, and it be cemented, there would be no seepage. Probably at the joints there would be a little.

The CHAIRMAN. What has been your experience with regard to irrigation on cultivated land? What does the land produce here?

Mr. JARVIS. Do you mean as to the acre?

The CHAIRMAN. No, I mean quantity, the value of the produce.

Mr. JARVIS. From orchards in full bearing I have taken as high as $300 for peaches, $250 for pears, $450 for oranges, and $250 for grapes.

The CHAIRMAN. Are those the net or gross returns?

Mr. JARVIS. Gross.

The CHAIRMAN. What would be the net return?

Mr. JARVIS. It would be about $150 for raisins and grapes, $125 for pears, and oranges $300. I have taken off a single acre of apricots $500, and that would net $450 or $350. My orchards, I wish to say, are not in full bearing, but the vineyards are in full bearing. My orchards have some years to grow before they will attain their best.

The CHAIRMAN. How long have they been growing to produce the results you have mentioned?

Mr. JARVIS. Last spring it was eleven years since I commenced to plant.

The CHAIRMAN. How are the best orange orchards? What do they yield in the gross?

Mr. JARVIS. There are some that yield in gross $1,100; others $1,000 and $800. Numbers receive $800—$600 and $800 are quite common.

The CHAIRMAN. Including the water, cultivation, planting out, and nursing, until you would commence to get results from an orange grove, what would it cost per acre?

Mr. JARVIS. That is modified very largely by the first cost of the trees. At the present time trees are expensive, and have been for three or four years. Prior to that, when we could buy trees for 75 cents each instead of $2, as we have been paying recently, an orchard could be set out very moderately. Then it would have cost $30 per acre per annum until they would commence to bear. Good budding trees will pay running expenses and possibly leave a small margin the fourth year. That is doing exceedingly well; but they do that occasionally.

The CHAIRMAN. For planting out and attending to them for three years until they commence to bear, about what is the gross expense?

Mr. JARVIS. The average would be about $300 per acre. That is taking it all around, and counting the medium price per tree at $1.

The CHAIRMAN. What is the land worth?

Mr. JARVIS. From $500 to $750 an acre, depending upon the condition of the trees.

The CHAIRMAN. What is the value of the land here where there is no prospect of irrigation?

Mr. JARVIS. About $2.50 an acre, depending upon the character of the land. If it is somewhat moist land, that will grow grain, it is worth from $25 to $50 an acre.

The CHAIRMAN. I mean such land as Riverside is on. Provided there was no chance for irrigation what would it be worth?

Mr. JARVIS. It would not be worth over $10 an acre.

The CHAIRMAN. Take the land itself now when you have water on it, but before you have put any trees on it, what is it worth?

Mr. JARVIS. From $250 to $400 per acre.

The CHAIRMAN. What is it worth after you have got on to it a four-years' growth of well-cared-for orange trees?

Mr. JARVIS. From $700 to $800 per acre.

The CHAIRMAN. What is it worth when the trees get to be ten years old?

Mr. JARVIS. Orchards have sold here as high as $2,000 per acre, and they are worth more, because they have paid an interst of 10 per cent. on that.

The CHAIRMAN. How long is the life of an orange tree that is well-cared for? Of course you have not seen the end of it here, but what is your opinion?

Mr. JARVIS. The history of the orange tree is that it has the longest life of any tree we have. In the old country they have orange trees in good bearing one hundred years old, and many of them older than that and in good bearing. Whether in this climate they will live that long is a question that will have to be decided by the future.

STATEMENT OF A. H. NAFTZGER, OF RIVERSIDE.

The CHAIRMAN. You may go on and make any statement you think would be of interest to the committee.

Mr. NAFTZGER. I wish to say what I think of the relative values of irrigated and unirrigated land. I think Dr. Jarvis has expressed my views exactly, except that I think the land that can not be irrigated is of no value at all. I would not pay taxes on it myself. So that the land that can not be irrigated, or has no prospect of being irrigated, I should consider as having no value whatever. A man might use it ten years to grow a little winter hay or barley on, but I should consider it to be absolutely of no value. With regard to lands that have water on them, I think Dr. Jarvis's estimate a fair one, from $250 to $400 per acre, depending upon the quality of the soil and its relation to the markets, etc.

The CHAIRMAN. Do you agree as to the value of the crops that the land will produce?

Mr. NAFTZGER. Yes. I judge from the results that have been produced and the sales that have been made. I think that Dr. Jarvis's estimates are certainly conservative.

STATEMENT OF MATTHEW GAGE, OF RIVERSIDE.

The CHAIRMAN. What have you to say as to your system of canals?

Mr. GAGE. About five years ago I purchased a tract of about 2,400 acres in Santa Ana River bottom, about 12 miles from Riverside. On that land I dug a number of trenches and bored a system of artesian wells, forty-two in number; in depth from 100 to 500 feet, averaging about 175 feet each. From these wells I have a flow of about 1,700 inches of water in the dry season of the year. That water comes from a strata of coarse gravel, sand, and bowlders that underlie the Santa Ana Valley. I have constructed a canal from the supply down to the land on the east side of the Colonnade, Riverside, 25 miles from the head. I have sold water-rights to about 3,500 acres of land along the line of the canal, and I have a tract of about 5,000 acres of my own, which I am now putting upon the market. I purpose distributing this water through iron pipes. The cost of that pipe system is about $12.50 an acre, in large tracts.

The CHAIRMAN. Can you do it as cheaply as that?

Mr. GAGE. I think so. It depends on the price of iron.

The CHAIRMAN. Describe the pipe you use.

Mr. GAGE. It is about No. 16 iron, and ranging in size from 8 inches to 4 inches in lateral distributing lines.

The CHAIRMAN. What means do you take to keep the pipe from rusting.

Mr. GAGE. A coating of asphaltum and some other things that practically preserve it for a great many years. With this system there can be no waste by seepage or evaporation, and the duty of the water under the Gage system is 1 inch to 5 acres.

The CHAIRMAN. Have you tested it so that you know you can get along with one inch to five acres?

Mr. GAGE. We have not tested it to the extent that the Riverside water people have; but from the general use of the water throughout the country we estimate that it is ample.

The CHAIRMAN. With the pipe system is it equal to 3 inches by ditches.

Mr. GAGE. No, it is 1 inch to 5 acres.

The CHAIRMAN. Will an inch serve five acres under the pipe system as well as an inch will serve three acres under the ditch system?

Mr GAGE. No; because the Riverside Water Company delivers its water on the land as I do; so that, with their system they have a greater use of water than we think necessary with ours. There is a difference somewhat in the soil and local conditions making the use of water varied. One inch to three acres on some land may not be any better than one inch to five acres on other land. We have considered one inch ample water to five acres under our system. We purpose cementing our pipes. We have a mile and a half down now through a line of tunnels. We purpose continuing it in places where the land is porous. We do not consider that the amount of water lost in seepage would compensate for the amount of money necessary to concrete the ditch.

The CHAIRMAN. All the way?

Mr. GAGE. Yes.

The CHAIRMAN. You only take the places where the land is porous.

Mr. GAGE. Yes. I would supply the money for the waste rather than for the concrete.

The CHAIRMAN. Is there anything further that you wish to state of the advantages of your system?

Mr. GAGE. There is nothing special in its advantages over the Riverside system.

The CHAIRMAN. What did you pay for your land?

Mr. GAGE. Six hundred and forty acres of it I paid $1.25 an acre for, and being poor at that time I could not deal with my friend Mr. Evans, and I had to go back and pay $75 an acre when I made it valuable.

The CHAIRMAN. What have you been selling your land for?

Mr. GAGE. From $300 to $600 an acre.

Adjourned.

SANTA ANA, CAL., *September* 2, 1889.

The committee met on the call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF JAMES McFADDEN, OF SANTA ANA.

The CHAIRMAN. What is your occupation?

Mr. MCFADDEN. Farming, and a number of other things.

The CHAIRMAN. Do you practice irrigation in this locality?

Mr. MCFADDEN. In part of it—the part toward the foothills. Perhaps from Santa Ana north toward the foothills they practice irrigation more or less.

The CHAIRMAN. In some portions of the country here you can cultivate crops without irrigation?

Mr. MCFADDEN. Yes; in some portions of the valley.

The CHAIRMAN. What crops do you raise?

Mr. MCFADDEN. Almost anything you can plant that grows in other parts of the United States—corn, barley, and potatoes.

The CHAIRMAN. The land is irrigated by the subsoil or dampness from below, which percolates from the river?

Mr. MCFADDEN. I do not know about the river. In that section of the country we get artesian water.

The CHAIRMAN. What crops do you raise where you irrigate?

Mr. McFADDEN. We raise almost any kind of crops that you put in. But the crop that needs irrigation most is probably the orange tree.

The CHAIRMAN. From where do you get your water with which to irrigate?

Mr. McFADDEN. In the Santa Ana river, mostly.

The CHAIRMAN. How extensively are you cultivating the orange tree in this locality?

Mr. McFADDEN. I am not sure about the acreage. Perhaps some of these other gentlemen can answer that question better than I can. If I were to answer, it would be only a guess. But, I suppose, in the Santa Ana valley there are perhaps 4,000 or 5,000 acres in orange trees. Do you think that is about right, in the aggregate, Mr. Taylor?

Mr. TAYLOR. I think fully that many.

The CHAIRMAN. What is the land worth before it is irrigated—the land that requires irrigation? If it could not be irrigated what would it be worth?

Mr. McFADDEN. If the orange land could not be irrigated it would not be worth anything for orange trees. But it could be used for something else.

The CHAIRMAN. What?

Mr. McFADDEN. For small grain; and without irrigation it would probably grow vines very well, most of it.

The CHAIRMAN. What is it worth with irrigation?

Mr. McFADDEN. Do you mean the land without the trees, or with the trees?

The CHAIRMAN. The land without the trees, but when you have water on it.

Mr. McFADDEN. Good orange land without the tree and with irrigation is worth from $300 to $500 an acre.

The CHAIRMAN. When the trees are upon it and five or six years old, bearing, what is it worth?

Mr. McFADDEN. I suppose some of it has sold for about $1,000 an acre.

The CHAIRMAN. What does an orange grove in this locality yield per acre when it is in good condition?

Mr. McFADDEN. I am not strictly an orange man, and I wish some other gentleman would answer that question. I have not followed that business much.

The CHAIRMAN. Have you abundance of water here for irrigation?

Mr. McFADDEN. Yes; we have quite an abundance in the river for most of the valley. We extend that irrigation over lands, perhaps, to a greater extent than we have water to cover.

The CHAIRMAN. You have not been under the necessity of attempting to increase the water supply?

Mr. McFADDEN. Not yet. We use most of the water at the present time that is needed.

STATEMENT OF D. M. BAKER, OF SANTA ANA.

The CHAIRMAN. What is your occupation?

Mr. BAKER. My occupation is that of editor—newspaper publisher.

The CHAIRMAN. And as such you have paid attention to the result of irrigation to the orange business, etc.?

Mr. BAKER. Yes; to some extent. I am a man, only a tax-payer, as well as the other gentlemen around here. To that extent it has been my business.

The CHAIRMAN. What is the net proceeds from an orange grove after it comes *to maturity, five or six* years old?

Mr. BAKER. If you want an average, I can give you facts from authentic and reliable sources. For the last year or two I know one gentleman, a Mr. Wall, our county treasurer, who has a 12-acre orchard, and two years ago it netted him $6,750. That orchard is about twelve or fourteen years old. He is exceedingly good at agriculture and horticulture, and has made that a business here for many years. Those are the figures he gave me, and he is as reliable a man as there is in the State. That is the net result of his orange grove two years ago.

The CHAIRMAN. That is over $500 an acre.

Mr. BAKER. Yes; that is over $500 an acre.

The CHAIRMAN. What would be his average profit?

Mr. BAKER. I can not give you the average. I think myself that was extremely large for the time. It was an unusually good yield, and an extraordinarily good season. What had been his average before, I do not know. However, every crop in the valley here up to that period was large; but he seemed by good management to realize more than the average person. I think a well-matured orange grove ought to realize $500 an acre with irrigation. I think our friend, P. T. Adams, realizes that every year. He lives down here a couple of miles.

The CHAIRMAN. Do they ever have much of a failure?

Mr. BAKER. Not unless they get affected by the booms. I have never known a man being affected in his orchard where he attended to his business.

The CHAIRMAN. That disease is subsiding to some extent?

Mr. BAKER. I think it has gone down to some extent. So far as I can tell, it has subsided considerably in southern California.

The CHAIRMAN. The people are now attending to their business?

Mr. BAKER. Yes; they have been for the last two years. It is a necessity that they should.

The CHAIRMAN. You say that your crops have been destroyed?

Mr. BAKER. Crops have been exterminated in this valley by disease.

The CHAIRMAN. You have not discovered what it is.

Mr. BAKER. I can not tell what it is. Mr. Pierce, the entomologist, says he knows what it is.

The CHAIRMAN. Has he suggested a remedy?

Mr. BAKER. No; he has not the slightest idea of a remedy.

The CHAIRMAN. Does it extend into your county?

Mr. BAKER. No, it extends from Fresno to Ensenada. He finds it at Riverside, and we thought it exempt. He finds symptoms of it at Fresno, and he finds it prevails all over southern California. He finds they are badly affected with it at Ensenada. He is preparing a report to make to headquarters.

The CHAIRMAN. You have had no difficulty in supplying all the water you want from Santa Ana river?

Mr. BAKER. So far as my experience goes we have never had any difficulty. I own land on the other side of the river, 10 miles from here. We have abundance of water there, and, in fact, the land I own requires very little irrigation. I have not put a drop on it for two years, and it is a large tract. All over the surface we find plenty of water. The land produces grapes, oranges, and lemons, all along.

STATEMENT OF E. E. EDWARDS, OF SANTA ANA.

Senator REAGAN. What is the territory that may be irrigated by the Santa Ana River?

Mr. EDWARDS. I should say about 60,000 acres.

Senator REAGAN. How much of that is now under irrigation?

Mr. EDWARDS. It is only a rough estimate; but I should say 20,000 acres.

Senator REAGAN. Is there any portion of the valley cultivated and in crops that is not under irrigation?

Mr. EDWARDS. Yes; especially the wet years. The San Juan Ranch, adjoining Tustin, has 115,000 acres. There are probably 40,000 acres of land that is level, nice for irrigation, but that has no water on it. San Juan Ranch, ever since I have known it, has been pastured with sheep until this year. This is the first year that I have seen any extensive crops on it.

Senator REAGAN. What crops?

Mr. EDWARDS. Crops of barley.

Senator REAGAN. Have they tried wheat?

Mr. EDWARDS. I do not know.

Senator REAGAN. You do not know what the production of barley to the acre has been.

Mr. EDWARDS. No; I can not tell you. I passed over it last week, and there are several hundred acres planted this year, and they were threshing it out. Here is Mr. French, who has been superintendent of that ranch for many years, and he could tell you more than I.

STATEMENT OF VICTOR MONTGOMERY, OF SANTA ANA.

The CHAIRMAN. State anything you think may be of interest to the committee.

Mr. MONTGOMERY. I came to this valley seventeen years ago, and there was very little land irrigated. The colonists at Anaheim had a few acres under cultivation and were raising vines. This side was struggling with a small ditch that they plowed out in furrows, and had a few hundred acres under irrigation. I have seen that extended from year to year, until I see now both sides of the river have in the neighborhood of 15,000 or 16,000 acres covered.

The CHAIRMAN. And 40,000 that has no water on it.

Mr. MONTGOMERY. Yes.

The CHAIRMAN. What would it be worth if it had water on it to irrigate it?

Mr. MONTGOMERY. From $250 to $500 an acre, depending on its accessibility to market.

The CHAIRMAN. Would it bring $300 an acre?

Mr. MONTGOMERY. I think it might.

The CHAIRMAN. And it is worth—how much?

Mr. MONTGOMERY. That land would sell for from $25 to $50 an acre, depending on its accessibility to market.

The CHAIRMAN. Water would add $250 to its value.

Mr. MONTGOMERY. Yes; San Diego Creek, that comes in about the range into the plain there, is a fine place for storing water, and storage reservoirs might be built all along that bench. When I first bought land there they were irrigating a few hundred acres of land, and now I think our system covers 2,000 acres. We put in a submerged dam and cement pipes, and we are using the same source of supply that our predecessors used. They used it all on a couple of hundred acres, and we are now irrigating 2,000 acres as successfully as they irrigated 200 acres, and with the same water supply.

The CHAIRMAN. You would not take much interest in Government

surveys. They would not help you much if there were no public lands to be reserved.

Mr. MONTGOMERY. In the valley I do not know but that public surveys would do good, because of the jealousy of local land-holders. There a man could have a source of water supply and might not want to divide with his neighbor, and I think it will have to be brought under some Governmental control before there will be enough water.

The CHAIRMAN. And you think there would be enough water in the Santa Ana River if it were all saved.

Mr. MONTGOMERY. Yes; I think a submerged dam could be put in profitably.

The CHAIRMAN. I should think 40,000 acres of land with $250 added to each acre would be a big inducement.

Mr. MONTGOMERY. That is in various holdings, and you could not get concentrated efforts, concentration of means.

The CHAIRMAN. Perhaps you might form an irrigation district.

Mr. MONTGOMERY. Our friends across the river tried that. We want to see how they get along. Without irrigation this country is comparatively worthless, and with irrigation I do not know what might be done here. Everything seems to be possible in the way of production. I do not think the estimate of profits on orange culture has been placed too high by Mr. Baker—$500 per acre for a good bearing orange orchard certainly is not too high.

The CHAIRMAN. Do you every year have the same demand for oranges?

Mr. MONTGOMERY. No. Some years the demand is not good. When the Florida crop is good we do not find ready sale for our crop here. But lately Florida has suffered and we have profited by it.

Adjourned

SAN DIEGO, CAL., *September* 3, 1889.

The committee met pursuant to the call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan, also Director Powell.

STATEMENT OF THEODORE VAN DYKE, OF SAN DIEGO.

The CHAIRMAN. How long have you resided in San Diego?

Mr. VAN DYKE. I have lived about fourteen years in this county.

The CHAIRMAN. What is your profession?

Mr. VAN DYKE. I have been engaged for the last four or five years in the development of the water supply.

The CHAIRMAN What enterprise?

Mr. VAN DYKE. The San Diego Flume Company principally.

The CHAIRMAN. Explain the purposes of that company.

Mr. VAN DYKE. It has an aqueduct that drains the water-sheds of the interior here and brings it upon the arid lands of the coast. A storage reservoir is its main supply of water during the summer. During the winter and spring the water is drawn directly from the rivers and streams.

The CHAIRMAN. What storage reservoirs have you?

Mr VAN DYKE. We have only one now of 2,000,000,000 gallons. It will cover about 1,000 acres about 4½ feet deep. That is its present capacity, and it is to be enlarged.

The CHAIRMAN. What is the duty of water?

Mr. VAN DYKE. That depends very much upon the amount of natural rain-fall and the retentive character of the land—about 9 inches deep, with proper cultivation.

The CHAIRMAN. Your reservoir will cover 1,000 acres how many feet deep?

Mr. VAN DYKE. About 4½ feet deep.

The CHAIRMAN. How much land have you?

Mr. VAN DYKE. Eighty thousand acres.

The CHAIRMAN. Do you think you can store water sufficient to irrigate that land?

Mr. VAN DYKE. Not by storage alone; but the natural flow of the streams and the tunnels will be sufficient for the whole of it.

The CHAIRMAN. What is the land worth before it is irrigated?

Mr. VAN DYKE. The greater part is of no value at all. About 60,000 acres would be worth nothing at all except for sheep, etc.—$1 an acre.

The CHAIRMAN. How much would it be worth under water?

Mr. VAN DYKE. We have had no test of that, because the water has been on the land but a few months—from $150 to $200 an acre.

The CHAIRMAN. Have you estimated how much it would cost per acre to put water on the land?

Mr. VAN DYKE. Twenty-five dollars, $50, and $75 in some places. That is on account of the sea-level, hauling it up a long distance, which makes it more expensive. We do not raise any grain in this country by irrigation, but everything else is irrigated.

The CHAIRMAN. You depend upon the rain-fall to raise grain?

Mr. VAN DYKE. Yes.

The CHAIRMAN. You raise what kind of fruits?

Mr. VAN DYKE. All kinds that are raised in California—grapes, pears, peaches, apricots, olives, oranges, etc.

The CHAIRMAN. Which of the fruits flourishes best here?

Mr. VAN DYKE. I think the lemon is of more permanent success. There are other parts that succeed as well on the oranges, at Riverside, for instance. The lemon, grape, and apricot are better here.

The CHAIRMAN. You have gone into the orange culture more than any place that we have noticed.

Mr. VAN DYKE. The olive does well here.

The CHAIRMAN. Under your water system 80,000 acres could be ultimately reclaimed?

Mr. VAN DYKE. Yes. Then there are several other systems that are being got under way; one at San Luis Rey.

The CHAIRMAN. Where is San Luis Rey?

Mr. VAN DYKE. About 50 miles north of San Diego. Then there are 20,000 acres at Fall Brook and 50,000 acres at San Jacinto.

The CHAIRMAN. They are not able to reclaim all the San Jacinto land?

Mr. VAN DYKE. No; they can not get water from there; it is too rough. There is more land than they could get water for. There are over 200,000 acres in that country.

The CHAIRMAN. What is the altitude of the mountains?

Mr. VAN DYKE. The highest point is 6,000 feet. The general average is 4,000 feet.

The CHAIRMAN. What is the rain-fall?

Mr. VAN DYKE. Two or three times what it is on the coast.

The CHAIRMAN. Then the rain-fall is very abundant in the mountains?

Mr. VAN DYKE. Yes.

The CHAIRMAN. What is the character of the country—its topography?

Mr. VAN DYKE. It is a slow rising country.

The CHAIRMAN. Has it a broad water-shed?

Mr. VAN DYKE. Yes, good water-sheds of all kinds and descriptions. It is only a question of expenditure of money. There is enough water to irrigate the whole dry area upon the coast.

The CHAIRMAN. About how much do you think that will amount to in acres?

Mr. VAN DYKE. Over 300,000 acres of the first class, and 100,000 acres more of the second class.

The CHAIRMAN. Are there any reservoir sites on the public lands?

Mr. VAN DYKE. No, all the reservoir sites have been taken. Most of the broad valleys have been taken up long ago.

The CHAIRMAN. But there would be no difficulty in getting water sites from private parties.

Mr. VAN DYKE. I have seen no startling evidence of that. They will not let you have them at the lowest price. They would a short time ago; but I would not gamble on that now.

The CHAIRMAN. Public opinion will produce a reaction.

Mr. VAN DYKE. I think it will eventually. I have been asked to prepare a condensed description of this county, which, with the committee's leave, I will present later on.

STATEMENT OF WILLIAM ENNEKING, OF SAN DIEGO.

The CHAIRMAN. What is your occupation?

Mr. ENNEKING. I am assistant secretary to the chamber of commerce here.

The CHAIRMAN. In this town?

Mr. ENNEKING. Yes.

The CHAIRMAN. Have you, at the suggestion of Senator Reagan, made a measurement of some of the products of the soil of this county?

Mr. ENNEKING. Yes.

The CHAIRMAN. Will you call off the articles that you have measured in this room.

Mr. ENNEKING. Stock beet, 46 inches long and 29 inches in circumference; squash, 150 pounds, 66 inches in circumference; pumpkin, 103 pounds, 76 inches in circumference; watermelon, 91 pounds, 50 inches in circumference; squash, 50 inches long, 17 inches in circumference; collard, weight 20 pounds, 27 inches in circumference; apple, 2 pounds, 14½ inches in circumference; pumpkin, 120 pounds, 86 inches in circumference; sugar beet, 30 inches long, 28 inches in circumference, weight 50 pounds; silver-skinned onion, 18½ inches in circumference, weight 2½ pounds.

The CHAIRMAN. Those are the vegetables and fruits raised in the county of San Diego, and they are on exhibition here in the rooms of the chamber of commerce?

Mr. ENNEKING. Yes.

The CHAIRMAN. They were produced by irrigation?

Mr. ENNEKING. Without irrigation.

The CHAIRMAN. All of them without irrigation?

Mr. ENNEKING. The majority of them.

The CHAIRMAN. Then there is no necessity for irrigation here.

Mr. ENNEKING. We do not need very much of it. This is the showing without irrigation. The majority of the people who irrigate think it might be double the size.

The CHAIRMAN. Do you know how much ground there is of the character from which these things were produced?

Mr. ENNEKING. I do not know how much there is.

The CHAIRMAN. Could you raise products of that character on these dry plains?

Mr. ENNEKING. Mesa land. Yes. A great deal is raised on the mesa land at San Marcus, at Tia Juana, and Oneonta.

STATEMENT OF GEORGE P. HENSLEY, OF SAN DIEGO.

The CHAIRMAN. Do you know on what lands the vegetables and fruits named by the last witness were raised?

Mr. HENSLEY. Some were raised at San Marcus, some at Oneonta, and some at Highlands; some at Cajon and different settlements through the county.

The CHAIRMAN. Raised without irrigation?

Mr. HENSLEY. The larger portion of them. In the San Marcus country they are raised without irrigation.

The CHAIRMAN. Is the country where you do not require irrigation extensive as compared with the country that does require it?

Mr. HENSLEY. No; the country that will be benefited by irrigation, as shown by our exhibits, will be two to one as against the land that will raise a full crop without irrigation.

The CHAIRMAN. Then there is twice as much land on which you can not raise full crops without irrigation as there is of the other kind?

Mr. HENSLEY. Irrigation is necessary to raise a full crop on twice the quantity of land as there is where crops are raised without it.

STATEMENT OF HENRY C. LANGREHR, OF SAN DIEGO.

The CHAIRMAN. What is your profession?

Mr. LA NREHR. Civil engineer.

The CHARMAN. Are you familiar with San Diego County?

Mr. LANGREHR. I am, sir.

The CHAIRMAN. Is irrigation practiced here, and, if so, to what extent?

Mr. LANGREHR. It is practiced very little; it is just at the initial point of irrigation; that is all.

The CHAIRMAN. Do you find it necessary to produce all around crops?

Mr. LANGREHR. It is essential to this county.

The CHAIRMAN. Can you raise crops without irrigation?

Mr. LANGREHR. I think some can; but that land is rather scarce.

The CHAIRMAN. The area is small?

Mr. LANGREHR. Very small, indeed. By irrigation I believe we could produce fifteen times as much as we can without it.

The CHAIRMAN. What extent of country have you in this county that is susceptible of irrigation?

Mr. LANGREHR. About one-fourth of the entire county. There are thirty-odd square miles that could be supported by irrigation.

The CHAIRMAN. That might be reclaimed by irrigation?

Mr. LANGREHR. Yes.

The CHAIRMAN. From what source would you obtain the supply of water?

Mr. LANGREHR. Part by artesian wells, part by reservoirs, and part by canals—about forty miles, for instance, leading from the Colorado to the interior of our great desert here.

The CHAIRMAN. If you were to take out the Colorado at the foothills of the mountains it would supply more than 30 square miles on that side.

Mr. LANGREHR. Yes.

The CHAIRMAN. In the 30 square miles mentioned do you refer to what is on the west side?

Mr. LANGREHR. On the mountain side?

The CHAIRMAN. On the west side of the mountains. How much is on this side?

Mr. LANGREHR. I do not know exactly, but it will probably amount to what I have already stated.

The CHAIRMAN. There are 30 square miles on this side.

Mr. LANGREHR. That is the approximate amount. Water can be raised by artesian wells, by these underground rivers that we have in this county, underground streams, and also, as I have said, by reservoir sites.

The CHAIRMAN. Are the reservoir sites which are in the mountains on private land or are they on public land?

Mr. LANGREHR. Some on public land and some on private land.

The CHAIRMAN. The public land is reserved; the Government gives that to the irrigator.

Mr. LANGREHR. I have found some that is part private and part public.

The CHAIRMAN. Of course if you take that you will pay the men who have it what it is worth?

Mr. LANGREHR. Yes.

The CHAIRMAN. Of course every man who owns it will be ready to sell it for what it is worth?

Mr. LANGREHR. Yes.

The CHAIRMAN. You represent the board of supervisors who extended to the committee the invitation on the part of the people of the county?

Mr. LANGREHR. Yes.

STATEMENT OF DOUGLASS GUNN, OF SAN DIEGO.

The CHAIRMAN. What is your official position?

Mr. GUNN. I am the mayor of San Diego.

The CHAIRMAN. You have a publication in your hand. Did you prepare that?

Mr. GUNN. I did.

The CHAIRMAN. What does it represent?

Mr. GUNN. It represents the climate, resources, topography, productions, etc., of this country.

The CHAIRMAN. Do you wish to file it with the committee?

Mr. GUNN. Yes. In here there are a number of questions answered, questions relating to the climatic conditions of the country and its rain-fall.

The CHAIRMAN. You made a report on the Colorado desert?

Mr. GUNN. At one time I did.

The CHAIRMAN. Have you that report?

Mr. GUNN. It is embodied in that book.

The CHAIRMAN. Leaving out what you find on the sloping hills and taking into consideration the alluvial land which is in a body, how much land is there here?

Mr. GUNN. I can not answer that question definitely. There are gentlemen who are capable of giving you definite figures in regard to that, and their statement would be better than a loose one from me.

STATEMENT OF THOMAS S. SEDGWICK, OF SAN DIEGO.

The CHAIRMAN. How long have you resided in San Diego?

Mr. SEDGWICK. I have been making my home here for the last year.

The CHAIRMAN. You have been familiar with it how many years?

Mr. SEDGWICK. Twenty years.

The CHAIRMAN. Have you paid any attention to irrigation and the water supply for that purpose?

Mr. SEDGWICK. To some extent, yes.

The CHAIRMAN. Have you any suggestions to make with regard to the Sweetwater Reservoir?

Mr. SEDGWICK. No; I can not say that I have.

The CHAIRMAN. Have you any suggestions to make as to the improvements that might be made in it?

Mr. SEDGWICK. No; Mr. Hinton was asking me some questions about it this morning. He asked me in regard to the principles of construction, and I made some explanations in that direction.

The CHAIRMAN. The Sweetwater Dam is that which we have visited to-day. Will you give us a general description of it in the absence of the engineer, Mr. Schuyler?

Mr. SEDGWICK. As you observed to-day, the dam is placed across the upper end of the ravine of the Sweetwater Creek, some 7 miles from its débouché into San Diego Bay.

The dam is 76 feet long at the bottom, and 396 feet long at the top, and 90 feet high. Its thickness at the bottom is 46 feet, and at the top 12 feet, including parapet and cornice, with a parapet wall on top on the up-stream side 3½ feet high and 2 feet thick, and a hand-rail on the down-stream side. The profile of the dam batters 15 feet on the up-stream face and 19 feet in three slopes on the down-stream face. (See profile, fig. 2.)

The horizontal plan of the dam is a curve of 213 feet radius.

The waste-weir is 45 feet long by 5 feet depth, divided into eight sections by masonry piers, inclined on the up-stream face to receive loose flash boards, which, when in place, increase the depth of the reservoir by 5 feet. A training-wall carries the waste water well away from the foot of the dam. It is estimated that the wasteway will allow a continuous flow from the full reservoir of 1,500 cubic feet of water a second, which is believed to be about the flood regimen of the stream.

The masonry of the dam is from the rock forming the walls of the ravine, laid in Portland cement mortar, with large, rough blocks, uncoursed or otherwise ranged, the down-stream face presenting an even face.

The reservoir formed by this dam is about 3½ miles long and about three-fourths of a mile wide at its widest place, covering 720 acres, and has a storage capacity of 786,390,000 cubic feet, equal to 5,882,248,000 gallons.

The catchment basin feeding the reservoir is estimated to cover 186 square miles, flowing by the Sweetwater River from the southern slopes

of the Cuyamaca Mountain, lying nearly east from the Bay of San Diego, and about 60 miles distant.

The distributing system comprises 57 miles of iron pipes varying from 36 inches to 6 inches diameter, and supplies water for irrigation to some 10,000 to 15,000 acres of land, including the town of National City and other outlying settlements.

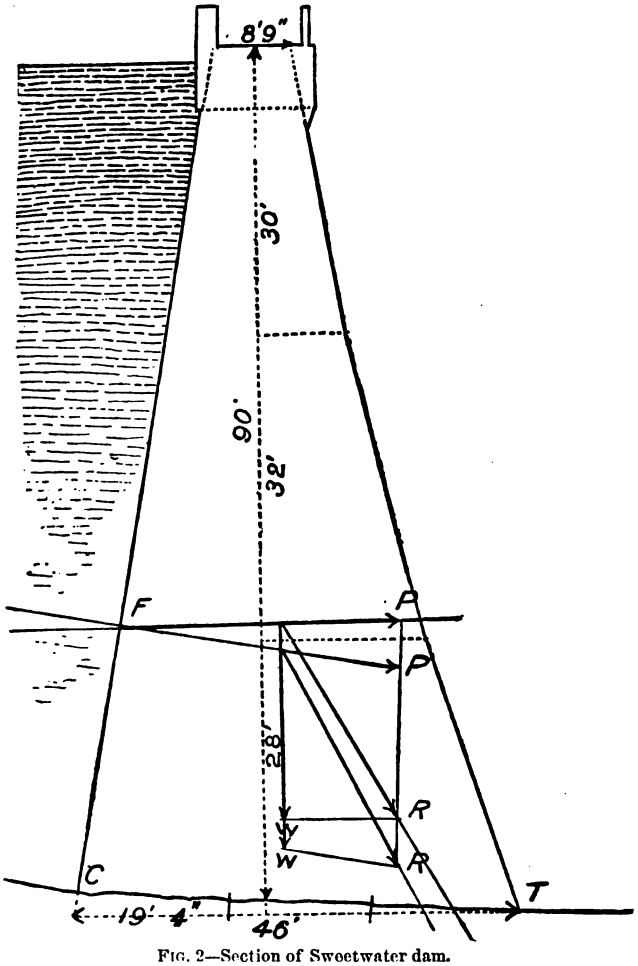

FIG. 2—Section of Sweetwater dam.

Q. Do you comprehend the principles of designing and constructing dams for the storage of water?—A. I believe I do.

Q. Will you kindly prepare a short paper on the subject, to be embodied in the report of the committee?—A. I will be pleased to do so to the best of my ability.

EARTH DAMS.

Embankments or dams for obstructing the flow of streams to form reservoirs of water may be successfully made of earth, for moderate *heights*, especially if suitable clays can be had by excavating for enlargment of the area, or depth of the reservoir, or in the near vicinity.

In such cases the embankments are wide on the base and have very flat slopes, generally from 2 to 3 feet horizontally on 1 of height. If the clay be of good character, such a dam or embankment will generally be impervious to the water; but if the clay be of uncertain imperviousness, a core of puddled clay or a thin wall of masonry may be placed in the middle of the embankment to render it water-tight.

The slopes are usually faced with hand-laid protection of stone or brick, clay tiles, or even boards, to protect the slopes from wear by overflowing water, and from sliding, which is prevented by the weight of the paving. If the embankment is to be constructed with a view to allow it to be submerged when the stream is in flood, the top of the embankment and its down-stream slope should be covered with a good quality of pavement to prevent injury from drift likely to be carried over the dam in flood stages of the obstructed stream. Often the waste-way extends along a part only of the dam, or is placed at either end thereof, as may be indicated by some favorable condition of the local-

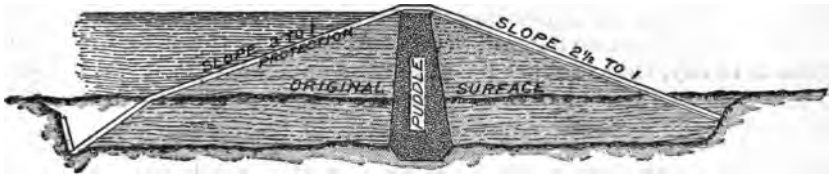

FIG. 1—Nethertrees reservoir embankment, Paisley, England.

ity. Figure 1 shows an earth-embankment dam of this description, which is a good example of English practice.

The original surface of the ground on which such an embankment is to be built should be removed to a stratum of consistent material of clay or earth, or to an underlying rock.

There is no mathematical principle of mechanics necessary to be applied to the construction of an earthen dam, with reference to its weight and the pressure of the impounded water, for the reason that material for the dam is usually plentifully at hand, and can be so economically obtained as to render the cost of putting it in the dam an almost inconsiderable item, with reference to the importance of the benefits to be derived from the success of the projected dam and reservoir. Such a dam will be of ample stability if it be solidly made, but it may fail because of infiltration of water through it when of faulty construction, so that it may crack from settlement, which may also break the puddle wall.

There have been a great many such earth-embankment dams made in India for irrigation purposes, some of which are believed to be two thousand years old. The material is said to have been carried in baskets on the heads of the laborers, and deposited so as to have been compacted by the continual tramping of the workmen, which would account for their solid condition. There are many such dams in England and in our own Eastern States.

When the cause of the failure of this type of dams has been investigated it has generally been found that the embankment had been badly constructed or had been carelessly taken care of. Such a dam at Estrecho de Rientes, Spain, gave way in the year 1802, causing the death of 600 people and destroying some $7,000,000 value of property. In 1864 the Dale Dike Dam, near Sheffield, England, 95 feet high, gave way,

causing the death of 300 persons and destroying much property. In 1874 a dam near the town of Williamsburgh, Mass., failed, and 150 persons lost their lives and $1,000,000 of property was destroyed. The most disastrous failure was that of the Conemaugh Dam, near Johnstown, Pa., in June this year (1889), completely washing away three or four villages, with a loss of some 3,500 lives and millions of dollars value of property. Unless the top and slopes of earth dams are well protected, the overflow water will wear away the embankment and destroy the dam.

MASONRY DAMS.

When the valley of drainage desired to be closed by a dam to form a reservoir is of less width, and requires a higher dam than is usually ventured to be made in an earth embankment, say, of 70 or 80 feet in height, stone masonry is resorted to as the proper material for the dam, and the mathematical rules of applied mechanics are taken into consideration and applied to the problem of proportioning the dimensions of the dam and disposing the forces acting on it in accordance with the science of civil engineering, so as to make the structure stable; that is to say, that it must be of such a weight that it shall not be pushed down stream nor overturned by the pressure of the water in the reservoir.

The forces to be considered in the construction of a masonry dam are the weight of the masonry and the pressure of the water resting against it. The weight of the material of the dam resting on its foundations is readily found.

The pressure of water against the vertical face of the dam at the top is equal to the weight of a cubic foot of water ($62\frac{1}{2}$ pounds) for the first foot of depth, and increases as the depth, so that at a depth of h feet it is $162\frac{1}{2}$ times the depth ($62\frac{1}{2} \times h$). Now, as the pressure at the top is nothing and at the bottom $62\frac{1}{2}\,h$, the average pressure is one-half of $62\frac{1}{2}\,h$, or $\left(\frac{62\frac{1}{2}h}{2}\right)$; and this multiplied by the depth h gives the whole pressure against the face of h feet height, and $\frac{62\frac{1}{2}h}{2} \times h = \frac{62\frac{1}{2}h^2}{2}$ is the algebraic expression for the pressure of water on a vertical face of the height h.

It is demonstrated in the text-books on engineering that this pressure acts by concentration at a point two-thirds of the depth from the surface of the water. If we consider the case of a dam of a given height, say, 100 feet, and 100 feet long, the pressure for each foot of length will be $\frac{62\frac{1}{2}h^2}{2}$ or $\frac{62\frac{1}{2} \times 100 \times 100}{2}$, or 312,500 pounds, and for the whole length of the dam $312{,}500 \times 100 = 31{,}250{,}000$ pounds. For the purposes of discussion of the sectional proportions of the dam it is usual to consider 1 foot only of length, which section is called its "profile."

Considering the dam to have a profile of uniform thickness, A B C D, Fig. 2, supporting 100 feet depth of water, the pressure is 312,500 pounds, as has just been computed. That the dam shall not slide on its base, it must have a weight equal to this pressure. For the purposes of this discussion stone masonry will be considered as having a weight of 150 pounds to the cubic foot; consequently our dam must have a sectional or profile area, to be found by dividing the weight of the pressure F (*312,500* pounds) by the weight per cubic foot of the masonry, which is

$\left(\frac{312500}{150}\right)$, 2,083⅓ cubic feet of masonry for each foot in length of full height. As our dam is 100 feet high its thickness must be $\left(\frac{2083\frac{1}{3}}{100}\right)$, 20.83+ feet wide on C D, the area of the profile expressing also the cubic feet of one foot in thickness of this profile.

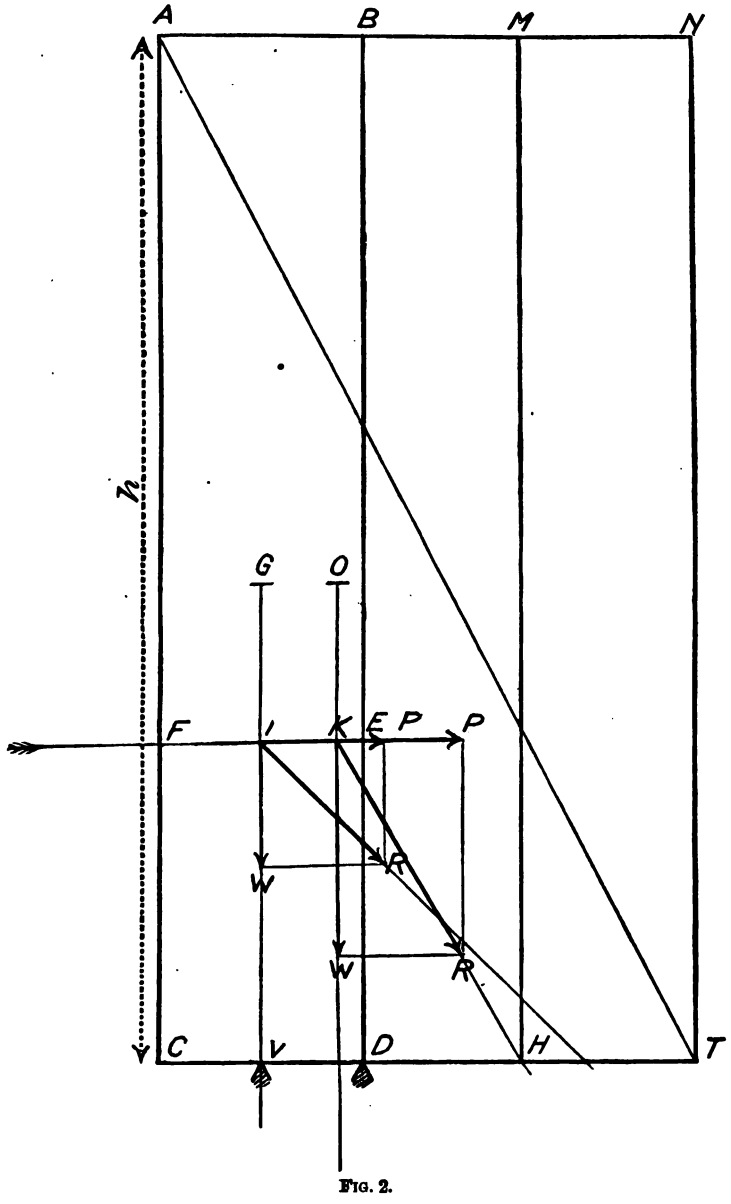

FIG. 2.

It is customary to increase the computed dimension of width by some proportion, as one-half, or by doubling it, to insure stability by increasing *the weight of the dam* proportionately.

If these forces—the weight of the dam and the pressure of the water—were just equal, the dam would yet remain in place against sliding, because of the friction of the masonry on its base, which is dependent on its weight and the surface of contact at C D, and has an established value for stone masonry resting on a rock bed of six-tenths of 1 per cent., which is practically equivalent to increasing the weight of the masonry by that proportion. If a good quality of cement mortar be used in bedding the masonry on its foundation, the shearing resistance of the mortar may, properly, be considered.

OVERTURNING.

The probability of the dam sliding on its base is not the only manner of failure to be considered. A more important problem is to so proportion the dimensions and profile that it may not be turned over down stream by the pressure of the water in the reservoir.

Referring to the last figure (2) we find the forces acting on the dam to be its weight, represented by its center of gravity G, acting in the vertical line G V, and the water pressure F acting in the horizontal line F P, at two-thirds the depth of the water. If from the intersection of the lines of action of these forces at I there be laid off, by scale, the proportionate values of the forces in the direction in which they act, we shall have the lines I W and I P, respectively, each scaled to represent 312,500 units (or 31), the weight and water pressure being equal. If from W and P the lines W R and P R be drawn parallel, respectively, to I P and I W, there results a (square) parallelogram I P W R, called in engineering language the parallelogram of forces, in which the diagonal I R is the "resultant" of the forces, representing the direction and value of the combined action of the two forces I W and I P. This value is readily found in this case by the well-known geometrical relation that in a right-angled triangle the square of the hypothenuse (or diagonal) is equal to the sum of the squares of the sides.

This resultant represents two principles, the first that if its equivalent force were applied to the masonry, and acting in that line, it would cause the masonry to slide on its base, disregarding friction of the base or the resistance of the mortar; the second, that as the line of the resultant passes out of, or cuts the down-stream face of the dam at a point above the down-stream toe D, its action is to overturn the dam by turning it around the point D. To resist and prevent such an overturning it has been demonstrated that the width of the masonry on its base C D must be enough to bring the resultant I R to cut the base C D inside of the point D.

To determine this width the moment of the forces W and F must be considered. If the masonry, considered as a column, were supported on a point at V (referring again to Fig. 2), vertically under the center of gravity G, the downward action would be equal to its weight, and a small force would hold it in equilibrium (upright) in the absence of the water pressure, but if the column were supported at the point D (as shown), the downward action would be much greater, so that a great force acting somewhere on the face A C would be required to hold the column in a vertical position. The force of the downward action of the weight W is found, or represented, by multiplying the weight by the perpendicular distance from the line of action of the force, or weight, to the assumed point of support; in this case this distance is V D *equal half* the width of the base.

This product is said to be the moment of the weight, or force, W about the point D, *minus* in this case $312,500 \times 10.41+ = 3,253,125$ foot-pounds moment. The force that, acting against the face A C, would hold the column in equilibrium, must have an equal moment about D, to be found by multiplying the force by its lever arm with reference to the same point D *minus* the perpendicular distance from the line of action F P of the force F to the point D, which will be E D. In the case of the water-pressure force applied at one-third the height h, F C = E D = $33\frac{1}{3}$ feet, the moment is therefore ($312,500 \times 33\frac{1}{3}$) 10,416,666 foot-pounds—$3\frac{1}{5}$ times the moment of the masonry weight, so that about one third of the water-pressure force would support the column in an upright position, and any greater force would certainly overturn it on the toe D.

The moment of the force F (water pressure) about the toe D being $3\frac{1}{5}$ the moment of the weight about the same point, proves conclusively that the column, or dam, would be overturned about D. To find the width of base C H, such that the column shall be stable against overturning, the moment of the weight must equal the moment of the water pressure (10,416,666 foot-pounds). If the base to be found be represented by x, the area (and cubic feet) of the column will be 100 multiplied by x ($100x$) and its weight that product by 150 pounds to the cubic foot ($100x \times 150 = 15,000x$), and this multiplied by the lever arm of $\frac{1}{2} x \left(\frac{x}{2}\right)$ gives $\left(15000\ x \times \frac{x}{2}\right)$

$$\frac{15000\ x^2}{2} = 7500\ x^2,$$

must be the moment to equal 10,416,666 foot-pounds. To solve this, to find the value of x, we must divide 10,416,666 by 7,500 = 1,388.8888+ for the value of x^2, and the square root of this—37.2678+ = x, and $\frac{1}{2} x = 18.6339+$. Substituting these values for x, and $\frac{1}{2} x$, in the last computations the results will be for the area and cubic feet of the profile ($100 \times 37.2678+$) 3,726.78 feet, for the weight (3,726.78 by 1.50) 559,017+, and for the moment ($559,017 \times 18.6339+$) 10,416,667 foot-pounds, proving that if the base C H be taken as 37.27 feet the moment of the weight will equal the moment of the water pressure. If now a new parallelogram of the forces be constructed (the center of gravity of the column having transferred to O, the center of A M H C, from K the intersection of the forces), we have K P W R, and the direction of the resultant K R cutting the toe H, indicating stability.

If the last found base be increased by its one-half to T = 55.90 feet, to secure stability, the weight of the masonry will be increased one-half, or to 838,525 pounds. One-half this weight is in excess of the weight found to resist sliding in respect of the water pressure (312,500 pounds), an excess of more than one-third (419,262—312,500 = 106,762), which would secure stability against sliding, so that if the profile of the dam should be divided in half by a diagonal line from A to T, thus dividing the masonry into equal parts, we yet have weight enough to prevent sliding, and finding the center of gravity of the triangle A C T, at G, at one-third the height and base from C, and constructing a new parallelogram of forces G P W R, Fig. 3, we will find that the resultant cuts the base inside the toe T, indicating stability with reference to overturning about the toe T. Now, as there is no material pressure of water at the top A of the dam, indicating very little thickness of masonry there, and finding that width of base is the requirement for

stability against overturning, we are led to the conclusion that the the oretic profile of a dam of stable equilibrium is that of a right-angle triangle, with the water resting against the perpendicular side.

Argument is not necessary to show that this form will bring th quantity of masonry to the least practicable weight.

Considering this triangle form of profile with reference to the equalit of moments of the forces about the toe T (Fig. 3), we shall have th

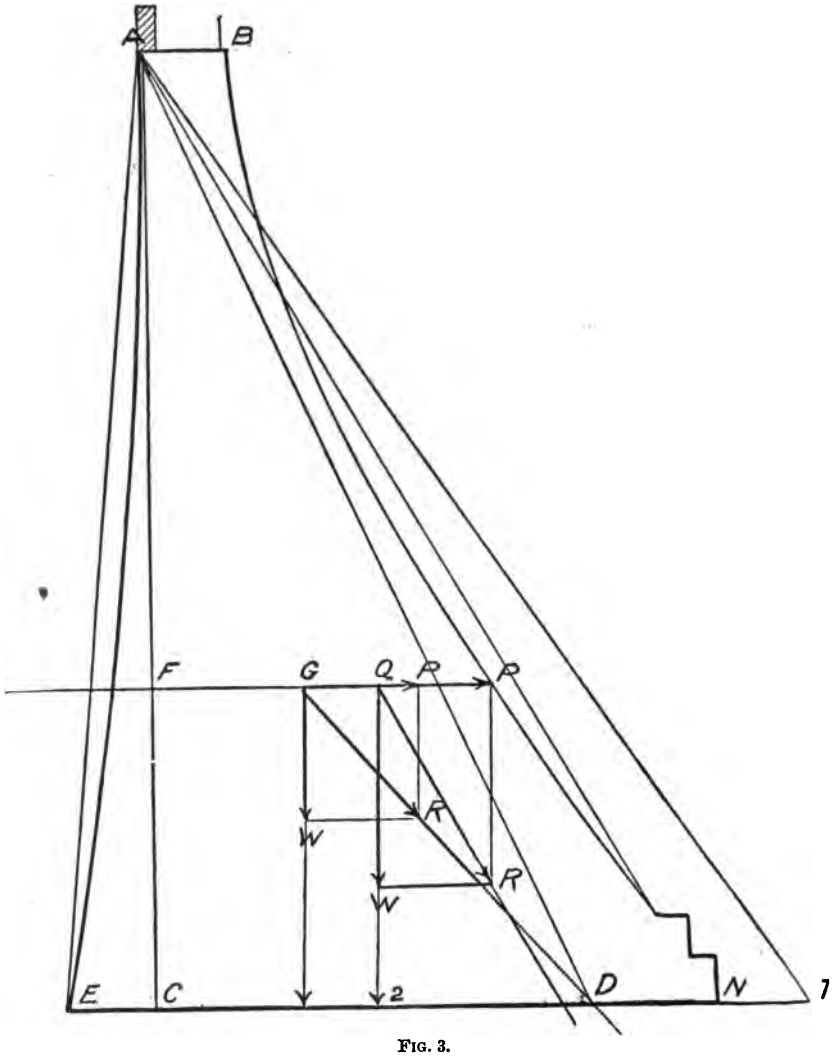

FIG. 3.

center of gravity of the dam (G) at one-third of its height above th base, and vertically above V, one-third of the width of the base C I from E, and two-thirds of the base from D, this last distance bein *the lever* arm for the weight W. Calling, again, the height of th

dam and depth of water h (100 feet), and its base x equal C D, the area and cubic of the profile will be $\frac{1}{2}hx$ its weight $\frac{1}{2}hx$ by 150 $\left(\frac{hx}{2} \times 150\right)$, and its moment $\frac{150\,hx}{2}$ by the lever arm V D $= \frac{2}{3}x\left(\frac{2x}{3}\right)$. Putting this in algebraic form $\frac{150\,hx}{2} \times \frac{2\,x}{3}$, and completing the multiplication we get $\frac{300hx^2}{6} = 50\,hx^2$ for the moment of the weight about the toe D. Putting this equal to the moment of the water pressure, as before, we have, substituting 100 for h, $5{,}000\,x^2 = 10{,}416{,}666$, and dividing 10,416,666 by 5,000 we have for the value of x^2 2,083.33, and extracting the square root of this number we find for the value of x (the base C D of the dam) 45.6435+ feet, which value will, if substituted for x in the last equation, make the moments of the two forces acting about D equal, for the weight of the profile of the dam will be $\left(\frac{100 \times 45.6435+}{2} \times 150\right)$ 342,326.25 pounds, which multiplied by its lever arm, two-thirds of 45.6435+ (30.429+) gives 10,416,666 foot-pounds, equal to the moment of the water pressure.

The weight of the masonry thus found (342,326.25 pounds) is nearly 10 per cent. in excess of the weight determined to guard against sliding on the base (312,500 pounds), so that the profile just determined is heavy enough to prevent failure by sliding.

As in the case of guarding against sliding, so in this case the base of the dam is increased in width to guard against overturning, and the members of the engineering profession have agreed that this increase, called co-efficient of stability, shall be one-half of the base, as above determined, making the base in this case 68.465+ feet = C T., only 13.5 feet more than was found for the final base of the masonry column dam.

By this increase of the bottom width of the dam, its profile area and weight are increased one-half, as shown in the triangle C A T, and its center of gravity is now found at Q, at one-third of the height and base from C, as for C A D, and acts in the vertical Q Y. For a new parallelogram of forces from Q we shall have for the water pressure, as before, 312,500 pounds, and for the weight of the masonry W (100 × 68.46 × 150 ÷ 2) 513,489 pounds. Completing the parallelogram of

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NOTE.—The algebraic expression of these relations is as follows: When h represents the height of the dam and the contained water, calling the weight of water 1, and of the masonry 2.4 ($62\frac{1}{2} \times 2.4 = 150$) $= w$, the moment of the water pressure will be expressed by

$$\frac{h^2}{2} \times \frac{h}{3} = \frac{h^3}{6}$$

and the moment of the masonry by

$$\frac{hx}{2}w \times \frac{2\,x}{3} = \frac{2\,hx^2w}{6}$$

Equating these expressions, we have

$$\frac{2\,hx^2w}{6} = \frac{h^3}{6} \text{ or } 2\,hx^2w = h^3.$$

Dividing by h and reducing $2\,x^2w = h^2$ and $x^2 = \frac{h^2}{2\,w}$ and $x = \sqrt{\frac{h^2}{2\,w}}$. Substituting the value of h and w, we have $x^2 = \frac{10{,}000}{4.8} = 2{,}083.33$, as before.

forces, we find that the resultant cuts the base somewhat within the point D. Now, as C Y was taken one-third of the base, C T for line of center of gravity Q, and D T is one-half C D, it is one-third the whole base, and equals C Y, and there remains Y T as the middle third of the base and it is cut by the resultant of the acting forces. The result of this disposition of the forces with reference to the profile, is the generally accepted maxim. *A masonry dam is stable when the resultant of the forces acting upon it cuts the base within the middle third.*

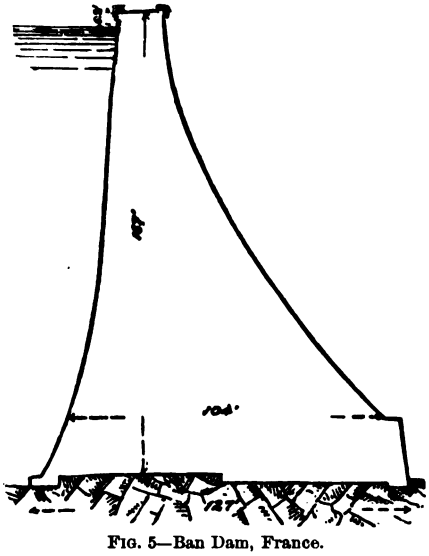

FIG. 5—Ban Dam, France.

If the upstream face A C of the dam be built with a batir or slope, C E, and the bottom width be kept the same as before, bringing T back to N, there will be no change in the area or weight of the profile. The center of gravity will be transferred upstream two-thirds of C E, and the intersection of the line of the resultant with the base will be changed by an equal distance, but will be nearer the down-stream toe by one-third of C E, reducing the co-efficient of stability by that amount, but at the same time the weight of the water resting vertically over the upstream batir C E may be considered as increasing the weight acting on the base E N, and also of the force W.

If there should be such a condition of over-fullness of the reservoir as would cause the water to overflow to a depth of 10 feet, the pressure F would be increased, and the point of action raised accordingly, reducing the stability of the dam proportionately. To avoid this effect a spill or waste-way is provided, generally at one end of the dam, through which the surplus water is allowed to flow away. The waste-way should have a capacity equal to the greatest known flood flow of the stream to be obstructed to form the reservoir.

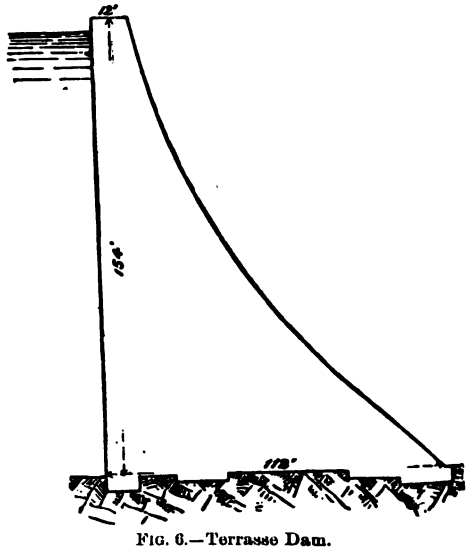

FIG. 6.—Terrasse Dam.

The dam may receive shocks from waves, or masses of ice floating on the surface of the water of the reservoir, which would to some extent affect the stability of the narrow top of the triangular dam. To guard against this effect, and to, *at the* same time, provide a convenient road-way from end to end of the *dam*, the top is given a width, A B, which is added to the down stream

slope A T or A N, in a curved form, as shown; and if a parapet wall be placed on the up-stream face, as shown, to prevent a flood overflow and cause the surplus water to flow through the waste-way, we shall have a complete dam; and if, further, we give the faces slightly curved batirs, as shown by the curved lines, we will have the standard scientific form of profile for masonry dams as shown by the profiles of the Bau, Ternay, Habra, and Terrasse Dams in France, where the profile and stability of masonry dams have been most thoroughly investigated and many dams built. (See Figs. 5, 6,7, 8, and 9.)

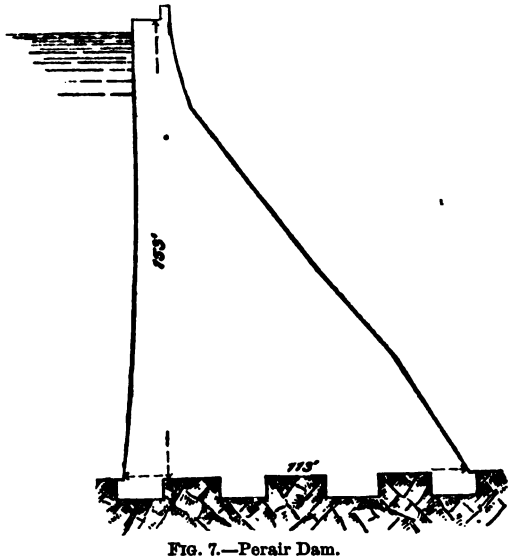

FIG. 7.—Perair Dam.

The value found for x, on page 367 (45.64+) may be taken for a constant ratio of base to height (0.456), for a difference in weight of 25 pounds per cubic foot in the masonry would not materially affect the stability of the dam.

The condition that the resultant of forces shall cut the middle third of the base is an arbitrary precept for a co-efficient of safety, and it might be assumed that were the resultant to cut the base within the second, fourth, or fifth, or even sixth of the base from the down-stream toe, the dam would yet be stable,* and because the cement mortar acts with a tensile force of, say, 10 tons per square foot at the face A C or A E, to prevent a rising or ruprute of the up-stream face, it enters into the co-efficient of stability, and may be considered as so much weight added to the masonry, in the same way as the column of water resting over the up-stream batir A D; and considering these forces (weights) as acting at the up-stream face, the center of gravity of the profile would be somewhat nearer the up-stream face, and the side G W of the parallelogram of forces would be lengthened, and the resultant would be brought farther within the base.

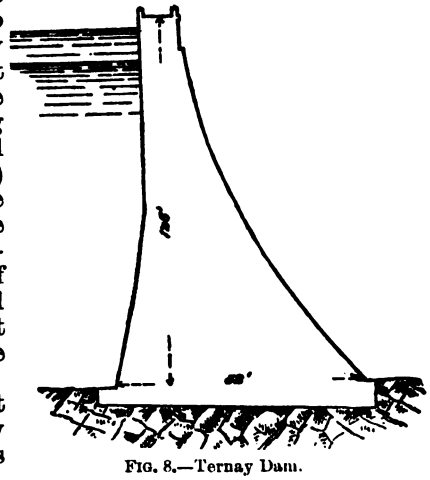

FIG. 8.—Ternay Dam.

The engineering profession is not agreed as to the precept of stability of a dam built on a curved plan, as in the case of the Sweetwater Dam, which has been described and a profile given.

*Reducing the co-efficient of safety to one-fourth or one-fifth or one-sixth.

The most notable case is that of Bear Valley Dam, near San Bernardino, Cal., which, above a bottom face, is 46 feet high, 2½ feet wide at top, and only 8½ feet wide at bottom. Its plan is on a curve of about 250 feet radius, and the resultant of forces cuts the base some 15 feet outside of the down-stream toe.

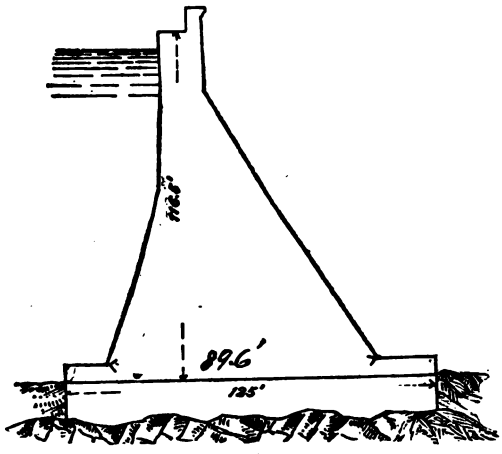

FIG. 9—Haba Dam, Algeria.

If the dam is so well built as to resist overturning as a solid segment of a ring, the center of gravity being between the segment and its chord, yet we must infer that the dam is held in place because cemented to its foundation, a force that may in good cementation amount to 20 tons per square foot.

THE CONSTRUCTION OF THE SWEETWATER DAM,* BY JAMES D. SCHUYLER, M. AM. SOC. C. E.

The question of an adequate water supply for irrigation as well as for the domestic use of cities and towns is one which in San Diego County, Cal., necessarily involves storage reservoirs. The streams of the county are of an intermittent character. The mountain ranges in which they head and from which they flow to the coast do not generally exceed 6,000 to 6,500 feet in elevation—an altitude too low in the latitude of San Diego to maintain perpetual snow upon their summits, or even to retain such proportion of the winter precipitation as comes in the form of snow (not usually more than 10 per cent.) for more than a few days or weeks. As a result the streams are torrential in winter and carry large volumes of water, but in summer and fall, when most needed for irrigation, are almost dry for 20 to 30 miles of their lower course, with the exception of certain seasons of such unusual rainfall that no irrigation is required—seasons that come at rare intervals. Ordinarily the streams in summer reverse the usual order of nature, and are largest at the small end, and to get a water supply the engineer must either go far back into the mountains and gather together a number of small living streams and springs and pipe them out long distances, or construct dam and storage reservoirs to retain the winter floods. Fortunately nature has compensated for the existing conditions by providing numerous favorable sites for such construction, and every stream of importance in the county has available sites for storage dams of large capacity. A number of water companies are engaged in preparing for extensive works of this character, which, when completed, will provide irrigation facilities for several hundred thousand acres of land otherwise unproductive.

This era of development was inaugurated but recently, and the first completed work of the character is the Sweetwater Dam and Reservoir and the extensive pipe system reaching out from it.

The circumstances which led to the building of the dam were that the San Diego Land and Town Company (a first cousin of the Atchison, Topeka and Santa Fé Railway), owned a large body of fertile and desirable mesa and valley lands bordering on San Diego Bay, adjacent to San Diego on the south, which were unsalable without water to irrigate them. These lands constitute the greater part of the "Rancho de la Nacion," including the town site of National City, which also languished with thirst. The Sweetwater River passes nearly through the center of the lands, and is of the nature described—intermittent in flow, at least for many miles above its mouth.

The first storm or two of the rainy season is absorbed by the thirsty earth, and the

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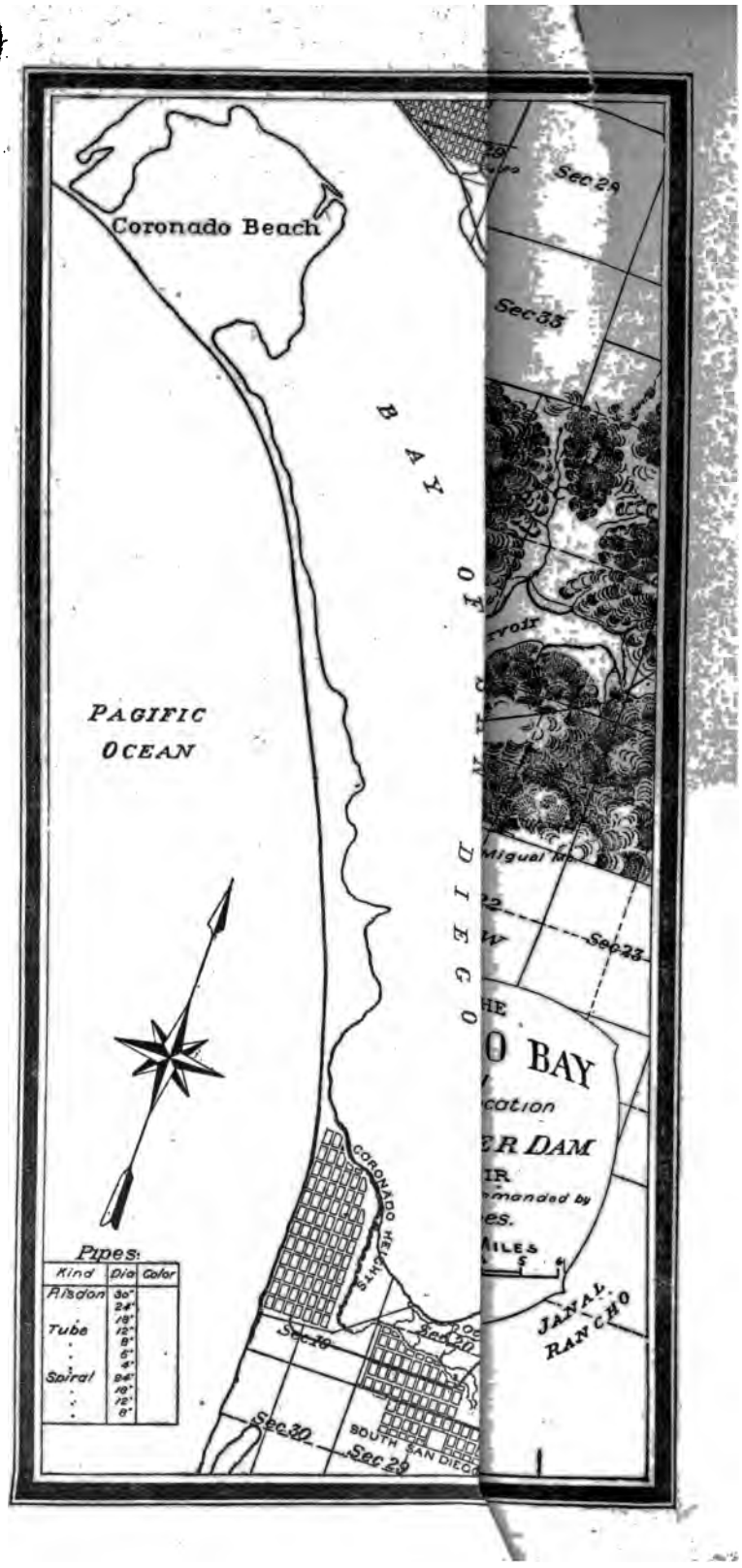
*Summarized by order of the chairman from "Transactions of the American Society of Civil Engineers," November, 1888.


Coronado Beach
PACIFIC OCEAN
BAY OF SAN DIEGO
Sec 29
Sec 33
Sec 23
Sec 19
Sec 30
Sec 29
BAY
DAM
CORONADO HEIGHTS
JAMUL RANCHO
SOUTH SAN DIEGO
Pipes:
Kind
Dia
Color
Alsdon
Tube
Spiral

stream generally does not begin flowing into the bay until late in December or in January. After each heavy storm thereafter its volume will reach 500 to 1,000 cubic feet per second for a few days, and within a fortnight recede to 10 cubic feet per second.

The last severe storms of the rainy season are usually in March, and the flow of the stream will generally dwindle to 1 or 2 cubic feet per second by June 1, which amount may be maintained through the remainder of the year, but not always. The large supply running to waste each year, followed by months of scarcity, naturally suggested storage, and the first cañon above the mouth of the stream was selected as the place to accomplish the object. This narrow gorge, 7 miles east of the bay, is a deep and narrow cut, half a mile in length, through a dike of trap rock or trachyte that intersected the valley of the Sweetwater, leaving above it a broad level valley some 3 miles long, one-quarter to three-quarters of a mile in width. This is the site of the reservoir formed by the dam built at the head of the gorge.

The construction of this dam was decided upon and work begun in November, 1886. The original plan designed was a narrow wall of concrete masonry, 50 feet high, 10 feet wide at bottom, 3 feet on top, arched up-stream. On the upper side an embankment of loose earth was to be filled in against the masonry wall to its full height. After two months' work had developed the character of the design, the plan was disapproved by the management, and the writer was called upon to design a suitable structure and execute its construction. Some $35,000 had already been expended, and in order to utilize as much of the old work as possible the new structure was planned to rest upon and incase the foundations already laid. This decision influenced to some extent the radius of the arch of the new dam, as well as its position relative to the axis of the cañon and the location of the anchorage on the sides. In other words, to avoid throwing away the work already done, the new work was adapted to the old in a way that ultimately increased the length of the dam on the crest somewhat more than would have been necessary by shifting the point of radius to one side of the central axis of the cañon, and making the radius somewhat shorter than it otherwise would have been. An engineer is sometimes driven to adaptations of this sort against his judgment, to save, or to give the appearance of saving, the pockets of his employers.

The modifications of the original plan were radical ones. The combination of earth and masonry was rejected, as it seemed to the writer that water alone was sufficiently heavy for the masonry wall to support without adding the last straw on the camel's back, of a mass of saturated earth. A gravity profile was adopted, and rubble masonry formed of blocks of stone up to 4 tons weight was substituted for bastard concrete composed of cement mortar, with small stones rammed into it, which had been previously used. So much of the old plan was retained, however, as to form an embankment 50 feet wide on top, 10 to 15 feet high across the cañon, against the face of the wall, but clay well rammed in layers was substituted for the silt and quicksand loosely dumped, with which the dam was formerly being made. The object of this clay filling was to cut off possible seams in the bed rock underneath the dam and reduce the pressure on the structure. The top of the embankment is 70 feet below the top of the dam.

The foundation.—After the bowlders, sand, and gravel had been stripped from the base of the dam on either side of the old work, the bed rock was found to be very irregular in surface, presenting the appearance of a number of pyramids and cones thrown heterogeneously together, but bound solidly in one mass and well polished by attrition. The rock was very close in texture and exceedingly hard. No attempt was made to cut out the bed in the level benches, as the unevenness of the bottom, as nature left it, gave the assurance that whatever movement might occur in the structure built on such a base there could be no possibility of its slipping or sliding on the base. Wherever there were seams in the rock they were invariably occupied by roots, and the excavation was carried down till the seams pinched out and the roots disappeared. The rock was then thoroughly scrubbed by hand, and a thin grout of pure cement applied with brooms, filling the minutest crevices and angles in the rock, before starting the masonry.

The side walls of the cañon required more excavation to reach a satisfactory anchorage than the bottom. The north side was composed of shattered rock scored with innumerable seams filled with red clay. In thismaterial the excavation was carried to a depth (perpendicular to the slope) of 20 to 25 feet before a solid ledge free from seams was encountered. This ledge lay with a slope nearly parallel with the surface slope, and in direction so nearly parallel to the radial line of the curve of the dam that it could not have been better placed to receive the arch thrust and formed a natural skewback. This was carefully stripped and treated with cement grout in the same manner as the base.

The abutment on the south side was against the end of a dike of trap rock, crossing over the hills to the south in a direction nearly parallel to a line passing through the center of radius and *dipping* westward at an angle of about 10 degrees from the vertical. *After cutting into the face* of this rock 5 to 10 feet all seamy, loose mate-

rial was stripped away, and a bedding that was deemed sufficiently good was obtained, although the rock was not as free from seams nor as solid in mass as the north abutment. However, the entire foundation is an admirable one, of rock in place throughout.

The plan.—The original height of 50 feet was arbitrarily adopted at the beginning of the work, without any special investigation of the quantity of water to be stored by a dam of that height, but was "guessed" to be sufficient for present necessities, and the estimate of its cost was considered to be about the limit of the expenditure the company cared to make on an experimental scheme. There was an immediate and pressing need for water, the rainy season was passing, and it was desired to get up a part of the structure as rapidly as possible in order to catch a partial supply for the coming summer. Accordingly, in compliance with this desire, the foundation was rapidly laid and the structure hurriedly carried up to a point where it was safe to begin catchment. The base of the dam was laid with a width of 36 feet, and at a height of about 15 feet above the lowest course it was drawn in to a thickness of 24 feet. At this level (whose elevation above tide is 140 feet) the lowest pipes pass through the dam. Above this level the structure was carried to a height of 45 feet, with a top width of 5 feet, base as stated of 24 feet, face batter (up-stream) of 1 to 6. In anticipation of a probable addition to the height of the dam in future, the back was built in three steps, to give an opportunity of bonding the new work to the old. The profile of this portion of the structure is shown in Plate XXX. It was a gravity profile, whose line of pressure passed within the inner third of the base. It was constructed in arch form, convex to the stream, on a radius of 225 feet on the face line at top.

During construction the stream was carried in a conduit 30 inches square through the masonry near the bottom of the original creek bed. But one storm of the season of 1886–'87 (a dry one) swelled the creek sufficiently to exceed the capacity of this conduit, and then it rose and ran over the top of the masonry for two days only, without injury. This occurred February 14 and 15, 1887, when the flow reached a maximum of about 500 cubic feet per second. The gate at the upper end of the conduit was finally closed April 20, 1887, and the conduit was filled solid with masonry from below. From that time until June 1, the catchment was about 80,000,000 gallons.

By the 1st of June the structure, as planned, was completed to the height of 60 feet above the bottom, 10 feet higher than the height originally contemplated. It contained about 7,500 cubic yards of masonry and had cost, all told (including the preliminary experiments), about $100,000. Meantime, surveys of the reservoir basin and water-shed had developed the fact that the 60-foot dam would impound 1,221 million gallons, whereas, its extension to 90 feet in height would give a capacity of nearly five times that quantity, or 5,882 million gallons. Also that the area of the water-shed tributary to the dam is about 186 square miles, of which one-third is above an elevation of 3,000 feet, and between that elevation and 6,500 feet. The water-shed was evidently ample to justify the hope that the greater reservoir would be filled almost every year of ordinary rain-fall. The increased volume of water stored would so largely extend the utility of the works, and give so considerable increase in security against the disasters following a severe drought, that the increased expense of extending the height of the dam while the working force and plant were on the ground and fully organized, seemed to be immediately justifiable. These arguments were embodied in a report, which was favorably considered by the directors of the company, and orders were given, about a fortnight before the 60-foot dam was completed, to extend the structure to a height of 90 feet.

This somewhat extended account of the growth of the enterprise from small beginnings is necessary to an understanding of the causes that led to the building of the structure in two sections rather than as a mass. The fact is that the work was nearly half done before all the conditions were thoroughly understood—conditions which ordinarily in works of such magnitude and importance are known, studied, and exhaustively discussed preliminary to the beginning of any work whatever.

In designing the plan of the higher structure, greater reliance was placed upon the arched form than in the lower dam, then approaching completion. The profile adopted was one which theoretically gave stability by its own gravity, but without as large a factor of safety. The line of pressure falls about the center of the lower third. It was reasoned that as the foundation was as near perfection as can be generally found, apprehension on that score was unnecessary—and the source of the failure of such of the great masonry dams of the world as have given way—insecure foundation—need not be regarded as a factor in this case. If one can imagine a monolith to be carved in the form of a true arch, of such weight and dimension that any section of it is capable of withstanding the pressure of quiet water against it to its full height, without sliding or overturning, and such a monolith be firmly wedged between the rock-bound walls of a narrow cañon, the possibility of its being ruptured, *displaced*, or destroyed from water pressure alone can not readily be conceived. Now, *if by the use* of rich cement mortar and the best of building stone a structure be *formed of the* same dimensions and in the same position, which in time becomes vir-

nally a monolith, based on the firmest of bed-rock, its stability must be equally assuring to the mind.

The dimensions adopted were the following: Base, 46 feet; top thickness, 12 feet; height, 90 feet; radius of arch, 222 feet on line of face at top. The face batter of 1 to 6 was carried to within 6 feet of the top; thence to the top of the parapet wall, vertical. The batter on the back started at the top with 1 to 3 for 28 feet; thence 1 to 4 for 32 feet; thence 1 to 6 to the coping.

The construction.—When the new work was begun at the base of the completed structure, special care was taken to secure a perfect footing for the toe. When the foundation was stripped it was found that there was a slight leakage at various points along the bottom of the masonry, amounting altogether to about 10,000 gallons daily. The only perceptible leakage through the masonry was along the sides of the waste conduit, which had been recently filled in, although there were moist spots all along near the bottom.

All the leakage was entirely cut off by the new work, although it was necessary to carry up small well-holes alongside the old masonry to within about 15 feet of the level of the water surface in the reservoir, and keep them pumped out, before it was safe to close them entirely. Water was standing in the reservoir at a height of about 35 feet above the base of the dam, and the small quantity of leakage, and the ease with which it was stopped, was considered a favorable test of the superior quality of the masonry.

The stone used was of two grades, a dark blue and a gray metamorphic rock, impregnated with iron. The gray stone is full of minute quartz crystals, and is of slightly less specific gravity than the blue stone, which carries more iron. It was obtained from a quarry opened in the face of a vertical cliff over 100 feet high, situated 800 feet below the dam. It has no well-defined cleavage, and broke out in irregular masses, although generally having one or more tolerably smooth faces. Numerous tests of its specific gravity gave its weight as 175 to 200 pounds per cubic foot. The average weight of the masonry in place was estimated at 164 pounds per cubic foot, which was the value used in the calculation of stability and strains.

Portland cement of the best obtainable quality was used in the proportion of one part of cement to three parts of sharp river sand. For the upper 4 feet next to the water a richer mixture of one to two was used. The sand was clean, sharp, and of the most suitable degree of coarseness to make the best of mortar.

* * * * * * *

The work was completed April 7, 1888, having occupied sixteen months in construction, including two months of delay on account of shortage of cement.

The total volume of masonry laid was as follows:

	Cubic yards.
In the dam proper	19,269.0
In the wasteway	481.2
In the inlet tower	376.8
In the conduit from dam to tower	182.0
In the gate-houses	71.0
In various accessories	127.0
Total	20,507.0

In this work 17,562 barrels of cement were used, an average of 1.17 cubic yards of masonry per barrel of cement.

The total cost of the dam was $234,074.11, distributed as follows:

Plant: Tools, etc		$6,236.76
Materials:		
Cement	$63,111.03	
Cement hauling	8,614.18	
Lumber	2,408.08	
Iron work	4,915.99	
Pipes, gates, etc	5,152.58	
Miscellaneous materials, powder, etc	3,229.84	
		87,431.70
Labor:		
Common and skilled labor	93,590.55	
Foremen	6,866.49	
Teams	19,696.12	
Engineering, salaries and expenses	10,555.20	
Clerical work	653.88	
Earth work (contract)	7,666.51	
Miscellaneous expenses	1,376.90	
		140,405.65
Total		234,074.11

The cost of the flowage tract for the reservoir is not included in the above. A little over one-half the land cost $16,426.93. The remainder is in litigation under an action of condemnation. A San Diego jury under the stimulus of "boom" prices awarded the owner $280 an acre, or a little over $100,000 for land, one-third of which was worthless, and the remainder unimproved. This judgment is being contested before the Supreme Court. The clearing and grubbing of about 300 acres of the reservoir basin cost $10,808.46.

The wasteway.—This important adjunct to the dam was carefully considered and proportioned to carry the probable maximum flow of the stream that may be presented for discharge, with a full reservoir. It is located at the south end of the structure, and is 40 feet in length by 5 feet in depth, divided into eight bays of 5 feet each. These bays are formed by piers of masonry, set at right angles to the flow, and provided with recesses on the upper face, in which loose flash-boards of 2-inch plank rest on an incline of 35 degrees from the vertical. Any set of boards may be removed from top to bottom, or the water may be held at successive levels from the top to the bottom of the weir by removing the top boards all the way across. The water falling over the weir drops into a series of pools, 3 feet deep, which relieve the structure of shock, and passes down an inclined plane with a fall of 1 to 10, until it is carried away from the dam a distance of 50 feet, and then plunges into the cañon below. The capacity of the wasteway is about 1,500 cubic feet per second. This may be increased to about 1,800 cubic feet per second by opening a 30-inch blow-off gate in the main pipe below the dam.

The inlet tower.—This structure is located 50 feet above the dam, nearly opposite its center. It is built of masonry, with cement mortar mixed two to one, plastered outside and in with two coats of mortar mixed with one of sand to one of cement. It is 16 feet square at the base for a height of 10 feet, where its form is changed to a hexagon, with walls of a uniform thickness of 3 feet to the top. Each of the sides of the hexagon measure 3 feet on the interior face. Into the walls of the tower are built seven cast-iron elbows, at an elevation of 10 feet apart from bottom to top, the upper one being 10 feet below high-water line. The bell-mouths of the elbows open upward, and are ordinarily closed with a plain valve or cover of iron. The design is to draw water from the surface at whatever stage it may be. When any one cover is removed, a basket screen is lowered in its place, fitting closely into the mouth of the elbow. Three pipes pass through the dam and enter the tower at the bottom. The two lowest pipes are of cast-iron, 14 and 18 inches in diameter respectively, and lie side by side. They are encased in concrete throughout, from the tower to the dam. On top of them is built a conduit of masonry with a circular orifice 40 inches in diameter, formed of walls 30 inches in diameter, in double arches. This conduit leads from the interior of the tower to the center of the dam, where it joins a pipe of ¼-inch boiler-iron, 36 inches in diameter, leading to the main gate immediately below the dam, and from this gate is carried the main pipe line down the valley. The smaller pipes are not at present used, except to supply a hydraulic ram throwing water to the keeper's house on the hill, 150 feet above, and to drain the tower when all the valves are shut. They are intended to be used for supplying a turbine and pump to throw water to a higher level than the dam will now reach.

As an illustration of the fact that masonry laid in Portland cement in the proportion of two of sand to one of cement may be made water-tight with care exercised in laying, this tower, and the conduit leading from it, may be cited. When they are empty the pressure from the outside at present is somewhat more than 20 pounds per square inch on the conduit and at the bottom of the tower, and there is no leakage in either of them.

The reservoir.—Red clay soil constitutes the bed of the reservoir basin, or the major portion, outside of the old river-bed and bottoms, and is of an impervious nature. The following table of area and contents of reservoir is presented:

Contour elevation.	Area.	Contents.	Contour elevation.	Area.	Contents.
Feet.	*Acres.*	*Gallons.*	*Feet.*	*Acres.*	*Gallons.*
145 (level of lowest outlet valve in tower)	3.51		180	200.77	835,851,000
150	10.72	11,640,000	185	272.22	1,221,355,000
155	17.12	30,577,000	190	326.96	1,710,583,000
160	43.10	79,631,000	195	397.85	2,302,261,000
165	75.21	175,819,000	200	463.80	3,005,642,000
170	113.40	329,546,000	205	538.94	3,824,197,000
175	153.75	547,069,000	210	630.94	4,778,549,000
			215	721.86	5,882,278,000

The table shows that 80 per cent. of the capacity of the reservoir is within the upper 30 feet of height, and that 40 per cent. is within the last 10 feet. This fact reduces within small limits the fluctuation of head on the mains after the reservoir is

once filled, and constitutes one of the reasons for increasing the height of the structure, as it enables the establishment of the probable limit of irrigation on the lands below, at a line not lower than 25 to 35 feet from the top of the dam. The irrigable area was thus largely increased, by reason of the decrease in fluctuation of depth in the reservoir.

* * * * * * *

There has been no lack of wiseacres who predicted the failure of the enterprise as a permanent irrigation scheme; and some of the most intelligent citizens of the country criticised the location of the reservoir so near the mouth of the stream, on account of its presumed liability to obliteration as a reservoir by reason of the deposit of sand and silt. A careful examination of the water of the stream at flood time, when it was most heavily charged with sediment, convinced the writer that fears of this nature were groundless. An estimate made, within reasonable limits, indicated one thousand years as the time when it might be expected to fill. Samples taken by the State engineer department of California of the water of the Yuba, Bear, and American Rivers, immediately below the hydraulic mines, yielded an average of only about one half of one per cent. of sediment. Were the Sweetwater as heavily charged, it might fill the reservoir basin in one to two hundred years, but the voids would still contain a considerable volume of water that would drain out and be available, and the utility of the reservoir would not be destroyed if it were entirely filled with sand.

The distributing system.—From the dam to the lower end of the cañon, 1,600 feet, the main pipe is 36 inches in diameter, and covered with masonry laid in lime mortar, plastered with cement. From this point it is reduced to 30 inches diameter, and follows the valley for 5 miles, and thence rises to the top of the Chula Vista Mesa 92 feet above sea level. Its entire length is 29.800 feet, and at its terminus the water is divided into two 24-inch pipes, one running south 1 mile, the other west half a mile, where it is reduced to 18 inches diameter, and is carried northward to and through National City.

At the terminus of the 36-inch main a blow-off gate is located, to be used as a relief to the wasteway of the dam in case of a sudden flood which might exceed the capacity of the wasteway, or to draw off the water from the reservoir if, for any cause, it was desired to do so.

Wrought-iron pipes were used throughout. The total length of mains and laterals that have been laid is 58 miles, with 5½ miles on hand to be laid this season. They are of three classes, viz, straight double riveted pipe; converse lock joint, kalamined lap-welded tube; and spiral riveted pipe. About 16 per cent. of the pipe was of the first class, 72 per cent. of the second, and 12 per cent. of the third.

The introduction of spiral pipe into the system was unfortunate, as it does not stand the test of transportation across the continent, and will have to be taken up and specially treated to make it water-tight. It will answer very well for sub-irrigation, if it could be properly controlled, but as it is laid in streets and avenues that system is not desirable or conducive to comfort in traveling.

The total cost of the pipe lines was as follows:

Pipe	$301,928.80
Freight	39,183.03
Distribution	6,271.06
Gates	1,849.62
Materials, tools, etc	5,932.57
Right of way and miscellaneous expenses	2,968.00
Pipe laying	144,630.78
Total	502,763.86

Probable duty of the works.—One of the most interesting questions to the stockholders of the company is the result that may be reasonably expected in the way of irrigation from such a reservoir. The assumption is made that in average years, say three out of five, the water-shed will yield a sufficient supply to fill the reservoir, besides maintaining the consumption through the rainy season, thus starting on the irrigation season about May 1st with a full reservoir. From May 1st to October 1st is the average season of irrigation—about 150 days. Where pipe distribution is in use, a fair average allowance in southern California is a duty of 10 acres per miner's inch (500 acres per cubic foot per second). There are instances of a much higher duty having been attained—a duty of oven 40 acres per miners' inch having been accomplished in one place. Allotting 700,000,000 gallons for the annual consumption of National City, and for loss by evaporation during the summer months, the remainder would yield a flow of 2,000 miner's inches per day for 200 days; with a duty of 10 acres per inch, this amount would irrigate 20,000 acres. In the course of time it is expected that a duty as high as 20 acres per inch will be reached, in which event a reservoir full may be extended over two years' time, and still irrigate 20,000 acres, and afford a domestic supply to the town of National City.

Water rights, giving to the purchaser simply the privilege of becoming a customer for water, have been sold on the San Diego Flume Company flume at the rate of $2,000 per miner's inch. At this rate the value of the irrigation supply of the reservoir is $4,000,000. The construction of the works has already added a value of $1,500,000 to the principal tract of 5,000 acres which has been supplied with a complete system of water pipes, and another million to the value of town property in National City, and lands in its immediate vicinity.

STATEMENT OF WILLIAM DENTON, OF SAN DIEGO.

The CHAIRMAN. You are familiar with the Colorado Desert?

Mr. DENTON. Yes.

The CHAIRMAN. Have you reported on it several times?

Mr. DENTON. Yes.

The CHAIRMAN. Are you willing to furnish us a copy of your report?

Mr. DENTON. I gave extracts to Mr. Berry, of the Union, and if I had time I would be willing to present the committee with a copy.

The CHAIRMAN. Will you send it to Washington at any time within six weeks?

Mr. DENTON. I will do so. It will afford me a great deal of pleasure to send it.

Adjourned.

PAPER PREPARED BY WILLIAM DENTON.

Agreeably to request, I have the pleasure of submitting my report upon the basin of the Colorado, situated in San Diego County, and in the northeastern part of the northern district of the peninsula of Baja California, Mexico, although a portion of this basin is in Mexico and outside of the jurisdiction of the United States, and might at first glance appear irrelevant to the matter which I propose to discuss; but that part of the basin situated north of the boundary line between the United States and Mexico is, practically speaking, dependent upon the Mexican side as a medium through which water must be introduced for the irrigation of an important part of the territory under consideration. The area of the land north of the boundary line (United States) that is susceptible of cultivation through irrigation is approximately 1,797,120 acres. Of this area, 1,336,320 acres, owing to its situation, would be irrigated from the Colorado River, the rest, 460,800 acres, from reservoirs that could be made in Jacume, Carizo, upper Vallecitos, San Felipe, which would collect annually in the vicinity of 50,000,000,000 gallons of water, sufficient if economically used to irrigate by pipe all that portion of territory on both sides of the basin, situated at a higher elevation than the canal, lands formed from the washings from the surrounding mountains, not from the alluvial deposits from the Colorado River or the marine deposits of the Gulf of California, of which most certainly the central and lower portions of the Colorado Basin are composed.

Although desirable to build the entire canal upon United States territory, it would be impracticable to attempt it, owing to the heavy excavations and embankments, together with shifting sand hills that would be encountered for a great distance, which would be not only very expensive, but a hindrance of such a character that it may be considered at present impracticable. There is no doubt in my mind that the time will arrive when these lands will become so valuable that an outlay would be warranted for the construction of such a canal from some point on the Colorado River at a sufficient elevation to enter the Colorado Basin at its northeast extremity, branching at that point and running down both sides of the basin to the boundary line, thus irrigating all the lands in the Colorado Basin between the foot-hills, and carrying a sufficient velocity to keep a clear channel. On account of the turbidity of the water, velocity will require serious considera ion.

Under existing circumstances I would suggest that the Colorado River be taken as a medium to irrigate the greater portion of the lands alluded to. that the matter be made international, that a canal be made (the main trunk) through Mexican territory from the Colorado River to the Cucupah Range of mountains, say a distance of 60 miles, at a point near the Siete Pozos (seven wells), that the canal be tapped with a branch canal, taking it through the sand hills at a natural opening near that point, thence following the eastern side of the basin with the canal to the northeast extremity of the basin and as much farther as possible, thence tapping the main canal

near the Cucupah Range, following the western side of the basin, meeting the canal that circuits the eastern side (see map). Naturally flood-gates would be established on the canal at suitable points, thus controlling the water supply as to quantity. Another plan: Making the objective or initial point the Colorado River, so that in passing Pilot Knob, in United States territory, the bed of the canal would be 200 feet above sea-level, and 466 feet above the lowest point near Salton, in the Colorado Basin, the bed of the canal being 15 feet in width, with slopes of 60 degrees. Carrying a depth of 5 feet of water with sufficient fall the canal would have an easy flow, bearing a large volume of water nearly the entire round of the basin, not, however, on the line of canal laid down and shown on the accompanying map, but more or less like that shown by the dotted lines in red ink. However, the dotted line does not extend a sufficient distance up the river to give the 200 feet at Pilot Knob. The entire line of the canal in the latter method would be in United States territory. It would, however, be expensive, demanding a large amount of fluming; also in passing through the sand hills the flume would have to be boardered over tight. However, before any of these suggestions (the smallest of which would require a large outlay) could be acted upon thorough surveys would have to be made, when, after the subject had received mature consideration, the most feasible plan of irrigation could be determined upon.

Formation of the soil.—The central portion of the basin is formed by alluvial and marine deposits from the Colorado River and the Gulf of California, composed of decomposed vegetable matter, lime, and phosphorus, a great deal of it sufficiently rich to export as a fertilizer. It is an erroneous idea to suppose that the basin is a deposit of alkalies, when in the basin proper there is hardly any of that commodity. On the eastern slope, it is true that there are portions of the country impregnated with alkalies, but not so much so but that mangel-wurzel, beets, date palm, sugar-cane, and tobacco could be grown in great abundance, as it is a well-known fact that those articles thrive better in alkaline soils than in others. All plants require salts of some kind for their nourishment; they are continual absorbers. I am now speaking of the general character of the soil, and do not wish to be understood as inferring that there are not some patches on this immense tract that are not impregnated with alkali and sulphur, so as to make the existence of vegetable life an impossibility. I know that such is the case. But comparatively speaking, taking the whole into consideration, the alkaline patches alluded to would cut no figure.

Having paid more attention to that portion of the Colorado Basin (during the last sixteen years) situated in Mexico south of the boundary line between the United States and Mexico, which is of a similar character as to formation and composition, I will give you the advantage of my experience and knowledge, both in regard to its resources and proper mode of development and utilization, and which would apply equally to that part of the basin that exists in the United States, although, to a great extent equal in soil, it must be taken into consideration that circumstances have not admitted it to be clothed with the prolific growths of vegetation that is to be found on the Mexican side of the line, for the reasons that it has been debarred the privilege of receiving seed at the time of overflows, owing to the land a short distance south of the boundary line having become raised by the deposits of alluvium at the time of the overflows, likewise aided by the winds collecting matter which has formed a backbone or elevation that now prevents the water from passing over. New River, and that called the Rio in Medio (Middle River), at the time of the overflow, water the basin. Middle River's mouth is a long distance above tide-water. Not so that of New River. The latter is caused by the backing up of the waters of the Colorado River by the tide of the Gulf of California at the time of the freshets, produced by the melting of the snows. The Colorado River runs at a velocity of 7½ miles per hour, the Gulf tide at a velocity of 10½ miles an hour.

Water runs through the Rio in Medio nearly every year, at any rate every freshet, but not in sufficient quantity to irrigate any great extent of country. Not so with New River; unless the freshet is sudden and great, the water does not reach farther than the Hog's Back, situated south and immediately in the vicinity of Purdy's, or Cerro del Volcan, which causes a barrier to the further progress of the water through this channel (see section of New River bed on accompanying map). Since this survey was made of New River, the bed has filled up considerably south of the Hog's Back, where previously steamers have navigated as far as Promontory Point; that was the Embarcadero (landing) of that section of the country; here large quantities of sulphur were shipped on the steamer and forwarded to San Francisco. At this writing, however, even a light-draught stern-wheel steamer can not approach this landing within 400 yards, except at extreme high tides. This, as a matter of course, could be remedied by a little dredging at a small cost. The waters that could be supplied by these rivers (New and del Medio) could be used to very little advantage without the aid of reservoirs and powerful machinery, so that in the event of irrigating the lands alluded to, I would suggest the plan of dealing directly with the Colorado River at a commanding point, sufficiently to water a vast territory without the further aid of machinery or reservoirs as far as the Colorado water is concerned.

If it should be found that the supplies from the projected reservoirs already alluded to were not sufficient for those lands situated at an elevation out of reach of the canal that circuits the basin, then by all means I should advocate the construction of reservoirs of a sufficient capacity to hold the needed supply, which would have to be situated at proper distances apart, and elevations that would command the situation; with such a necessity, powerful machinery would be required to lift the water from the canal to the reservoirs.

The lands on the Colorado and New Rivers, to which I have already referred, and are more clearly set forth by the accompanying map, are rich beyond description, being composed of clay alluvial from the Colorado River and marine deposits from the Gulf of California, a great portion of which are annually overflowed, leaving rich deposits, which would prevent the land becoming impoverished, no matter how heavily cropped. The present wild growth is a species of wild hemp (*Sabomica Macrocarpia*), hog weed, or wild beet, that attain a height of 15 and 20 feet and a diameter of 5 inches. The latter plant is valuable as food for hogs, in its green state, and when dry it is excellent as fodder for horses and cattle. It produces a large quantity of seed, which fattens stock of all kinds very rapidly. And now a word in regard to the hemp, which covers large sections of the lands described.

With reference to this as a hemp country, we have the evidence that it is indigenous, of a superior quality, and at this present moment there are thousands of acres of last year's growth now standing, which simply requires to be gathered and broken and placed on the market. It compares very favorably with the Kentucky hemp, is equally as strong, and nearly as fine a fibre; it makes an excellent article of rope, matting, bagging, and paper, specimens of which can be seen in San Francisco in its broken, dressed, and natural states. Although this hemp is generally sown in ordinary good land, growing to a height of 7 feet, and twice as thick as a wheat straw, here it grows to the height of 20 feet, and 3 inches in diameter. There can be seen thousands of acres in a body that attains the height of 15 feet, and three-fourths of an inch in diameter. These plants are annuals. Besides the fiber which the hemp produces, it yields a heavy crop of seed, on which animals greedily feed. As a fattening food there is nothing superior; besides large quantities of excellent oil could be made and produced therefrom. There are other fibers in small quantities of a finer growth. Annual grasses of a nutritious character grow here, which mature in less than two months after the waters recede.

The timber is cottonwood, willow, and mesquite. The latter tree yields a fine nutritious honey bean, which fattens all kinds of stock very rapidly. The soil is from 10 to 40 feet in depth, strongly impregnated with lime and phosphorus, owing to the immense deposits of shell-fish and other matters.

Potable water can be obtained at a depth of say from 10 to 40 feet.

The soil and climate of this section of the country are susceptible of producing cotton, tobacco, hemp, which is indigenous, as well as the Manilla, New Zealand, Indian, and South American fibers, of which I should recommend the introduction; rice, sugar-cane, sugar-beets, pepper, ginger, peanuts, sweet potatoes, plantains, bananas, oranges, grapes, and all fruits and cereals of temperate and semi-tropical zones. Corn has attained the height of 25 feet, yielding from three to four ears of rare proportions and quality; the finest field of corn I have ever seen was grown in this basin, planted by the Indians without any cultivation or irrigation. I feel satisfied that on the western rim of this basin both tea and Liberia coffee would do well. In portions of Bajai California are grown rice and dates equal if not superior to any other grown in the world. The date-palm grows prolifically throughout the peninsula of Lower California, particularly the far-famed black date of San Ignacio, which surpasses all other kinds in yield, size, and flavor. This tree is peculiar in its necessities, adapting itself to the most sterile and arid localities; after the first year of its planting it requires no water. The most inferior portions of this country, and those impregnated with alkali, can be utilized with profitable results by the introduction of this tree. A good healthy tree in full bearing will yield annually 60 pounds (let us say 20) without looking after, except the picking and drying of the fruit, packing, and marketing; after the first year no cultivation or irrigation is required.

Let us hear what General Charles P. Stone, who was chief of commission for the survey of the Occidental States of Mexico, including Lower California (of which I had the honor of being a member), and who afterwards went to Egypt and formed that army. Writing from there in regard to the date-palm and the Colorado Basin, in answer to a letter of General W. G. Le Duc, Commissioner of Agriculture, in Washington city, under date of January 28, 1878, says:

"WAR OFFICE, BUREAU OF THE GENERAL STAFF,
"*Cairo, Egypt, January* 28, 1878.

"SIR: I have the honor of acknowledging the receipt of your letter of the 3d instant, informing me of the safe arrival of the red date seed, etc.

"Had I known that you desired to plant the date seed in large numbers the quantity sent would have been much greater, and I have now given orders for the collection of several thousand seeds in each of the northern districts, where the best dates are grown.

"The provinces of Charkieh, Gharbish, and Dahkaleeych, as well as the district of Roseta, all produce in the northern portion excellent varieties of dates, the cultivation of which is very profitable. From what I have seen of the date-producing regions of this part of the world, and from what I know of the desert of the Colorado between Carrisso Creek and Fort Yuma, I am inclined to believe that the greater portion of the latter region can be made productive and very valuable by making plantations of the date palm.

"This tree not only does not require much water, but much water is prejudicial to it, and the climate of the Colorado Desert is singularly similar to that of some of the best date-producing districts here.

"In any case, I feel assured that all of the New River portion of the Colorado Desert would grow the date tree without difficulty.

"Such is the opinion of an able man with a world-wide reputation, who thoroughly understood the subject and whose word is authority."

Extensive forests of eucalyptus could be planted which in five years would not only beautify the surrounding country but would render a respectable revenue to the planters, as it affords an excellent timber for ship-building, wagons, etc., and firewood equal to the best maple.

The countries of which it is indigenous are free from all kinds of fever, the leaf of this tree being an absorbent of malaria, and on account of its sanitary and other useful properties large quantities of it have been planted all over the East Indies and part of Africa by orders of the English and French Governments. Taking into consideration the extreme richness of the soil, and during the greater portion of the year the mildness of the climate, there is no reason why this tree should not attain the stately proportions that it does in Australia. The sugar-beet, mangel-wurtzel, sugar-cane, rice, bananas, corn, and tobacco could be grown with great success and most profitable results. The pig-weed (*Heracleum*, Bot.), which grows to such immense dimensions, I have already alluded to as being of the best family. There are certain portions of this basin that are peculiarly adapted to the production of the best tobacco, sugar-cane, and dates; I allude to those slightly impregnated with alkaline matter; indeed, the most luxuriant date trees, the most prolific growth of sugar-cane and beets, I have seen growing in lands strongly impregnated with alkaline matter.

Any quantity of beets, mangel-wurtzel, and sugar-cane could be grown on these lands, which not only would supply food for immense herds of stock but would yield a large amount of sugar annually, which would be quite an item to the commercial world, and particularly so to San Diego.

The climate is hot for four months of the year—June, July, August, and September; the other eight months are pleasant, and during the four very hot months there is a ventilation that does not allow it to become very oppressive or sultry. The ventilation that I allude to I attribute to the breeze which springs up in the afternoon carried (I presume) by the vacuum which the heat produces in the Mohave Desert (this being its out-let). The cool air, comparatively speaking, rushes in from the Gulf of California, thus to an extent cooling the atmosphere.

Were this country utilized by cultivation, planted with groves of trees adapted to the climate, with the introduction of water on a liberal scale, the whole face of the country would not only be changed, but the temperature would be decreased many degrees.

In conclusion, I will give you the opinion of Prof. Justin S. Moore, president of the botanical department of the California Academy of Sciences.

CALIFORNIA ACADEMY OF SCIENCES,
San Francisco, June 16, 1879.

DEAR SIR: You have requested of me my views of the soil, climate, and flora of the region of the mouth of the Colorado River, especially of that portion lying below the Algadones Rancho, in Lower California, and extending westward therefrom.

I have watched with interest your efforts to bring this region to the attention of our people of this coast, as well as to the notice of foreign immigration seeking good locations.

In the month of February last, in company with a gentleman well known in commercial circles in California, I paid a visit to the land above mentioned. In some respects the time of year chosen was unfortunate, in that the season of vegetation was passed and everything showed to its worst advantage.

I must say, however, that in every respect I found things as you represented.

The soil is of a rich alluvium, annually enriched by a deposit (slight) from the river, and a still greater deposit of carbonaceous matter from the decay of the rank

vegetation. In no portion of North America have I seen a soil that will at all compare with this in fertility. It closely resembles, however, the soil of the delta of the Nile.

As to the flora observed by me, I herewith append a list; I am sure it is at best a meager list, as compared with what might be found in the proper season of the Gramineæ. I have added nothing, as both flowers and seeds were absent, and consequently the species were not determinable. At one or two places I saw the alfalfa thriving without irrigation; of the Cryptogams I saw but few, and those as yet I have not determined. The more useful plants, which abound, are the various species of the *Prosopis, Parkinsonia, Sesbania, Philibertia, Tessaria, Salex*, and *Populus*.

No one who rides through the rank growth of *Sesbania, Philibertia*, and *Tessaria* can deny the evidence of his senses, that in this tract is to be found as rich soil as earth affords, capable of supporting as dense a population as any region on the globe. I have, therefore, no hesitation in saying that any and all semi-tropical plants may there be grown to the greatest advantage and with the certainty of a large yield.

Of the climate, I can only say that it resembles that of the countries of the Old World lying on the same isogeothermal line.

While it is much warmer than the climate of the coast region, it is yet far more pleasant than that about Fort Yuma.

This is no doubt due to the fact that a constant current of air is passing from the Gulf of California inland to the basin of the Colorado Desert: this current is more or less laden with moisture, and so comes as a refreshing breeze. I can see no cause to apprehend anything like miasma, for the reason that the presence of so large a body of salt water, together with the constant air currents passing the ground, is hostile to any miasmatic influences.

From those who have spent much time in this region, and especially along the river, where misama might be expected if anywhere, I learn that nothing of the kind has ever been known.

It seems to me, in view of all these circumstances, that no fairer land, no richer soil, or better climate can be afforded on this continent.

But one thing is needed, and that is the hearty co-operation of the Government of the Republic of Mexico in the grand enterprise you have undertaken, and for which you have spent and are spending so much of your time and such liberal sums of money. But for your efforts, I am sure our people would not as yet know of that vast and fertile region.

Already you are beginning to see the fruits of your unremitting toil.

Should now your Government second your labors, as they so richly deserve, I predict that it will be but a short time ere you will have the pleasure of seeing prosperous colonies settled on the tract, and the entire frontier be reaping rich advantage from thriving communities, cherishing the arts and manufactures, and developing the resources of the country.

Very respectfully, yours,

JUSTIN S. MOORE, A. M.,
Member California Academy of Sciences, San Francisco.

WILLIAM DENTON, Esq.

LIST OF PLANTS GROWING ON THE COLORADO BASIN, FEBRUARY, 1879.

Parkinsinia Aculeata Sinn.
Parkinsinia Microphylla Tove.
Parkinsinia Tarreyena Watson (Palo Verdi).
Prosopis Juliflora D. C., (Algaroba).
Prosopis Subuscens "Tounilla."
Salia Longifolia (Huhl).
Topertus Manilifera.
Chilopsis Saligna Dobn, (Desert Willows).
Tessaria Borealis Gray (*Cashamulla* or arrow wood).
Sarvea Mexicana Mor. (*Gobernadoia* or *Hidonia*).
Baccharis Enongi (Grey).
Datura Diocolvi Beruh.

Sesbania Macrocarpa; this is the so-called hemp, or Indian hemp, as that is an Apocynum. This is a very valuable plant for the fiber, for paper-making, etc. It is used by the Indians for making huts. There are thousands of acres of it in the tract. The other fine fiber found on the tract may be *Sinum Aristatum* (England).

There is another fibrous plant which I am sure will prove useful for paper stock, viz, *Philibertai lineare*, Var., Heterophyllun. It is abundant and will pay. Of the grasses I can not speak, as I did not find them in a condition to determine.

JUSTIN S. MOORE,
President Botanical Section California Academy of Sciences.

In conclusion, I will say that for the last thirty years I have been familiar with the Colorado Basin and its surroundings, and in regard to the statement of Professor Moore, touching the sanitary condition of that country, I can thoroughly indorse his statements. There is neither natural disease nor fever of any description; nor have I ever known or heard of a case. As an evidence of the salubrity of the climate, see the Indian to the manor born. No finer race of man (beautifully developed, free from sickness) exists on the face of the earth. Professor Moore said that he preferred to come to the Colorado Desert to see the grander living statuary—grander than any dead statuary that can be produced in either Athens or Rome. He remarked that fact alone speaks for the climate and soil of this section of the country.

A greater portion of the Colorado Desert north of the boundary line between the United States and Mexico is of a similar character to that which I have just described, having the same composition and made from the same sources, with the same climate and the same necessities, requiring the same aid, labor, intelligence, and energy to make it yield vast wealth which would appear nearly incredible, making the entire basin the wonder of the west, second in importance to no Delta of the Nile or any other area of the same size on earth.

As an engineer, I have made the utilization of that portion of the basin below the line, or in Mexican territory, a study for many years, and I think that I fairly understand the subject, not only in regard to the plan for irrigation but also as to a proper system of cultivation and cropping. The same system or plan of operation is applicable to the entire Colorado Basin.

STATEMENT OF F. H. HEALD, OF ELSINORE.

The CHAIRMAN. Where do you reside, Mr. Heald?

Mr. HEALD. At Elsinore, San Diego County, Cal.

The CHAIRMAN. How long have you resided in southern California?

Mr. HEALD. Since 1877.

The CHAIRMAN. At what places?

Mr. HEALD. Los Angeles, Pasadena, and Elsinore?

The CHAIRMAN. How long have you resided at Elsinore?

Mr. HEALD. Since June, 1883.

The CHAIRMAN. Have you had any experience in irrigation?

Mr. HEALD. I have had considerable.

The CHAIRMAN. Please state it.

Mr. HEALD. I have irrigated for myself and others several years at Los Angeles and Pasadena. Have developed water by wells, tunnels, submerged dams, and other ways, and am conversant with the Los Angeles and Pasadena systems as well as with others. I own two artesian wells (hot water); also a water system, supplying the city of Elsinore, 6 to 13 inch iron pipe. I own Elsinore Lake by virtue of succession of title to La Laguna Rancho, No. 495, descending from the Mexican Government, in which the United States Government has no vested rights.

The CHAIRMAN. Will you state length, breadth, and depth of Elsinore Lake?

Mr. HEALD. It is about 6 miles long, 2½ (average) miles wide, and from 35 to 80 feet deep, with a crater or center, the area and depth of which are unknown to me.

The CHAIRMAN. What is the source of supply of Elsinore Lake?

Mr. HEALD. The San Jacinto River and its water-shed, and various cañons of the Elsinore Mountains.

The CHAIRMAN. What is the area of its water-shed?

Mr. HEALD. About 522,000 acres.

The CHAIRMAN. Is the water of the lake fresh?

Mr. HEALD. It is fresh water from mountain snows and rains, but purifies once a year during the summer. There is an outlet to the lake at Temescal Creek, which flows into the Santa Ana River. The lake does not overflow, except in seasons of more than average rain-fall. A

dam could be made at the head of the Temescal Cañon, which would increase the area about 2,000 acres and increase the depth 30 feet.

The CHAIRMAN. How much arid land is there in the vicinity of Elsinore which would be benefited by irrigation?

Mr. HEALD. I estimate 25,000 acres. Land not needing irrigation I estimate 4,000 acres. The altitude of Elsinore Lake is 1,280 feet.

The CHAIRMAN. Could the water be piped or conducted to irrigate arid lands in this or San Bernardino County?

Mr. HEALD. Yes.

The CHAIRMAN. Are you in favor of storing water in mountain cañons by means of dams?

Mr. HEALD. I am not.

The CHAIRMAN. State your reasons.

Mr. HEALD. Great floods have occurred during my observation in this country in the winter season after the ground has become thoroughly saturated with water and then aided by a sudden and warm rain which rushes down the steep slopes and carries with it the water converted from melted snows. In this way thousands of lateral cañons and gulches pour their waters suddenly into the main cañon or river (already carrying all the water which it can with safety), creating a volume and force which no dam or obstruction created by human hands can withhold. At such a time the breaking of a great mountain reservoir and the adding of its waters to the flood might cause great loss of life and property. We build for future generations as well as for ourselves, and must remember that with water for our arid lands our population would be continuously increased.

FURTHER STATEMENT OF DOUGLASS GUNN, MAYOR OF SAN DIEGO.

This county is bounded on the north by San Bernardino and Los Angeles Counties; on the east by the Colorado River, dividing it from Arizona; on the south by the Mexican Territory of Lower California; on the west by the Pacific Ocean. Its area is 14,969 square miles, or more than 9,580,000 acres. Exclusive of the Colorado Desert section and of the mountain country lying adjacent on the east, there are over 3,000,000 acres of valley and mountain land adapted to a diversified agriculture and grazing. There are several large Mexican grants in the county, yet it is true that their aggregate acreage, as compared with the total area (exclusive of desert lands), is not large. The figures of the United States surveyor-general's office give the following:

	Acres.
Total area	9,580,000
Mexican and Spanish grants	784,783
Public lands	8,795,217

An approximately correct statement of the lands of this county, as open to settlement and purchase (1888), would therefore be as follows:

	Acres.
Total area (exclusive of desert)	3,000,000
Grants (still unsubdivided)	275,965
Subdivided grants	508,818
Public lands (settled and unsettled)	2,215,217

Two mountain ranges run through our county from northwest to southeast, dividing it into three districts, each possessing marked peculiarities of climate and soil.

The coast belt, between the mountains and the sea, is exceedingly

fertile; it has now three-fourths of the population and exhibits most of the development of the county. This belt varies from 25 to 40 miles in width and is about 75 miles in length, comprising a series of low, rolling hills, or "mesa" lands, as they are termed—plains and valleys—drained by the Tia Juana, Sweetwater, San Diego, San Bernardo, San Luis Rey, and Santa Margarita Rivers, and several smaller streams. These streams are nearly all dry in the summer months for several miles from their outlets. The San Diego is the largest of them, and in the winter and spring is often unfordable.

The middle division of the county lies mainly between the two mountain ranges, and comprises numerous broad and fertile valleys and plains, over which thousands of sheep and cattle may gaze all the year; while in the mountains are rich mineral deposits and extensive forests of timber. The natural wealth of this important division of the county is very great, and it is capable of supporting a large population. The cereals and all the fruits of the temperate zone grow here luxuriantly, and the apple, the cherry, and the plum are especially at home. Orchards are multiplying in this section.

The third, or desert division, lies east of the second, or San Jacinto range, of mountains. The peak of San Jacinto, at the northern end of the range, is the highest land south of Mount San Bernardino, rising precipitously to the height of 9,000 feet, and its snow-crowned summit appears in strange contrast to the sweltering desert which it overlooks. Along the eastern base of this range extends the great Choahuila valley, 50 miles in length by 10 in width, connecting southerly with the valley of the New River, which flows from the Colorado in time of freshets and fructifies the fertile lands along its bottoms. The Southern Pacific Railroad crosses this division, entering San Diego County from the San Gorgonio Pass, and running thence across the desert southeasterly to Yuma about 160 miles.

FURTHER STATEMENT OF T. S. VAN DYKE, OF SAN DIEGO COUNTY.

SOILS AND THEIR CULTIVATION.

San Diego is the most difficult of all the southern counties to examine. Its coast line, like the southern coast line in general, gives little indication of what lies beyond it, and seemed almost worthless without irrigation. The thousand springs and streams of its high mountain ranges, where the winter rains are always heavy and frequent, and where the snow often lies several feet deep for weeks, sank from sight in underground channels and deep beds of granite sand miles back from the coast line. Moreover, its arable lands are broken into hills and dales, rolled aloft in table-lands, mountain valleys, and parks, and scattered over a space larger than the State of New Jersey. This makes it impossible for any one to see any considerable portion of it except by days of constant travel.

No one, then, can form a correct idea of the present value of Southern California land without knowing how the Californians themselves have changed their opinion thereof within a few years. Up to twelve or fifteen years ago the low bottom lands were deemed far the most valuable; the uplands or slopes being of little use except for stock range and the raising of hay and grain in winters of abundant rain. A few years ago, although it was becoming generally known that the uplands were the best for vines and fruits, especially when irrigable, yet

in the partition of the large ranchos the bottom land was still rated at from three to five times the value of the best uplands. Not only were the bottom lands deemed more valuable because the surface was nearer to water beneath and more easily reached by water from the larger streams, but they were considered the only really rich lands there were. The uplands, being hard and dry, were often nearly bare of grass, and what there was seemed small beside the luxuriant growth on the loose soil of the damp alluvial bottoms. In time it has been found that the uplands only need good plowing and thorough cultivation to equal in production the best bottom lands; while the warmer nights in winter, cooler days in summer, their greater freedom from spring frosts, combined with superiority in the quality of nearly all fruits, make them far better for nearly everything but corn, alfalfa, and a few other products. The scale of values has been quite reversed; the uplands were irrigable, being about the only lands now sought for fruit-growing and attractive homes, while the low lands are used more for pasture or ordinary farming. For this purpose they are still very valuable, but it is a value that has close limits, while the uplands, being sought by people of wealth in pursuit mainly of comfort and places fit for the raising of the choicest and most tender fruits, have a constantly rising value, the end of which none can foresee.

The Mexican method of irrigating was to constantly drench the land from their shallow ditches. This practice was blindly followed for years by the Americans, who supposed that six or seven months of clear, warm weather would kill anything not rooted in wet ground. As population has increased and irrigable lands became scarce, moist lands along the river bottoms were tried; but it was many a year before any one supposed that the dry uplands would raise anything. First, it was discovered that these would raise as good grain as the low lands, provided there was winter rain enough; while in winters of excessive rain they would raise better grain, and in some winters of moderate rain-fall they would also do better, because the warmer nights permitted constant growth while the colder nights of the bottom lands often checked it until the ground was dried out. As arable land became scarcer the plow crept gradually farther away from the moist lands and up the drier slopes, until it was gradually learned first in the north, then in the south, that ground once thoroughly wet, then thoroughly plowed and thoroughly cultivated during the dry season, will retain enough moisture up to within a few inches of the surface to keep alive and in good condition during the longest, hottest, and driest summer almost every kind of plant or tree that is grown in rows or hills. For some things, such as oranges and lemons, this is generally insufficient to raise a good quality of fruit. For others, such as raisins, deciduous fruit, when the trees are well grown, corn, potatoes, etc., it may also be insufficient to produce very profitable results in some years. In no case is it quite equal to the same thorough cultivation combined with a little judicious irrigation. The arable soils of Southern California, though very varied, may be classed under two heads, the granite and the adobe, though there is sometimes a mixture of the two that at first glance resembles pure adobe.

The adobe is mainly clay and is of four prominent colors, though these sometimes shade into one another. These are dark, light-grayish brown, red, and dark brown. They are all very strong soils, probably standing longer cropping without fertilization, rest, or rotation than any other soil in the United States. They are, however, all hard to *work unless* taken in the right stage of moisture, when they are very

tractable, and then if well cultivated they retain moisture as well as any soil. With sufficient moisture they raise the heaviest grain, and for some kinds of vegetables, such as beets, and for such fruits as pears they can not be excelled. The granite soils are all formed from the disintegration of the soft red or gray granite which forms the bed rock of most of the interior hills. This soil generally lacks that fine rich shade which elsewhere is deemed a sure test of goodness. The eye can not be relied upon as a judge of any soil in Southern California. Even that which appears to be pure sand, when well treated to seed and water, under the California sun, will give results that will astonish the most experienced farmer or gardener from any other land. These granite soils run through all shades of color between dark red, caused by the presence of iron, and light gray, and through all degrees of fineness from the fine red soils which show no mica, unless dissolved in water, to heavy gray sand coarse enough to make a gravel-walk.

WATER.

Thus far the area has been estimated as plow land pure and simple. Ninety-five per cent. of it needs no clearing whatever, none of it now needs fertilization, and for many kinds of products never will need any. It does, however, need water.

The rain-fall increases with elevation, as has been stated already. There are four different rain-belts caused by this change. Other changes can not be accounted for in this way. Thus Fallbrook has generally more rain than many other places having a greater elevation and distance from the coast; while the coast line above the Santa Margarita River has generally more than the coast below. Still the general rule is that the rain-fall depends upon elevation, especially where a broad tract is elevated. The general impression that San Diego is a dry country has been caused by the constant publication of the rain record of San Diego City to prove that it has the best climate in California, to-wit, the driest.

The following is the rain-fall by seasons for San Diego City for fifteen years. This record is compiled at the United States signal station at San Diego, and is the only accurate one at hand:

Years.	Inches.	Years.	Inches.	Years.	Inches.
1871–'72	7.18	1876–'77	3.65	1881–'82	9.44
1872–'73	7.41	1877–'78	16.10	1882–'83	4.92
1873–'74	14.95	1878–'79	7.81	1883–'84	25.97
1874–'75	5.48	1879–'80	14.48	1884–'85	8.60
1875–'76	9.46	1880–'81	5.20	1885–'86	16.62

Thus it will be seen from this that the rain-fall is very variable. The difference between the different rain-belts is most apparent in the years of very low rain-fall.

The second rain-belt is shown by the rain-fall at Fallbrook, where there we have a record for eleven years as follows:

Years.	Inches.	Years.	Inches.	Years.	Inches.
1875–'76	17.51	1879–'80	20.45	1883–'84	40.25
1876–'77	8.75	1880–'81	11.45	1884–'85	12.78
1877–'78	24.84	1881–'82	12.24	1885–'86	26.50
1878–'79	8.52	1882–'83	10.60		

The third rain-belt, best represented by Bear Valley, Santa Maria, Viejas, and similar elevations within that range, has about 35 per cent. more rain than Fallbrook.

The fourth, or high mountain belt, is best represented by the rain-fall of Julian, 4,200 feet high, and about 40 miles from the coast.

There is but five years of reliable report.

Years.	Inches.	Years.	Inches.	Years.	Inches.
1879–'80	30.63	1881–'82	29.28	1883–'84	61.42
1880–'81	25.89	1882–'83	41.31		

A record of the snow was kept in only one of these years, 1882–'83, when it was 5 feet, making 7 inches of water which are included in the 41.31 inches. Reference to the San Diego table shows this to be the driest winter on the coast since 1877. As a large proportion of the water at this elevation is every year precipitated in snow, especially in wet years, it will be safe to add about 20 per cent. for snow to the other four years. This snow-fall increases, of course, with elevation, and on the high mountains it often takes weeks to melt off. Following the analogies of elevation from the coast upward, it would be safe to add at least 35 per cent. more for the next 1,000 feet of elevation. The average rain-fall is doubtless 50 inches at 5,000 feet.

Our high rain belt embraces forty townships, being 1,440 square miles, or 921,600 acres of land. As most of this is quite steep hill-side with a tight soil, the amount of water that runs off is fully 60 per cent. Of the remaining 40 per cent. fully 30 per cent. finds its way seaward under ground, trickling out in thousands of springs and rivulets which in the mountains combine their water into little brooks and run all summer, but as they approach the coast sink in sand, or into the soft granite bed-rock or old under-ground channels, and disappear.

The drainage of this broad highland area forms seven rivers which in wet winters often carry water enough all the way to the coast to float a large steam boat. They are often impassable for days at a time. During the summer they generally cease running above ground except in a few spots where a small thread may run for half a mile or so. Water may however generally be found in abundance a foot or two below the surface of the sand. In years of excessive rain these rivers flow to the coast all summer. In years of low rain-fall the excess above the summer flow is only in the mountains, the water though in abundance there serving only to fill up the sand and under-ground channels below.

The irrigation possibilities of this country are far beyond what they are generally supposed. The lowest rain-fall recorded anywhere on its area of highland in fifteen years was at Mesa Grande in 1877, where at an elevation of 3,500 feet the fall was 24½ inches. At Pine Valley, 30 miles south, and same elevation, the rain gauge for the same year gave 25 inches. Reducing the percentage of water running off to 40 per cent. we have about 10 inches. Twenty inches being sufficient for full irrigation we have water enough lost by surface drainage to irrigate 450,000 acres of land, to say nothing of the amount that afterward drains from below the surface. And this for the driest season yet recorded. As a matter of fact, however, water that will cover land 10 inches deep will serve very well for irrigation, though it is not enough for the best results.

The proportion of this drainage that can be secured for irrigation can not be easily estimated, as it is in most cases merely a question of what expense the present value of the land will justify. There are many places where large reservoirs may be made in the mountains to catch the flood waters there, many others where they may be made in the lowlands and water from the mountains led into them, many others in the lowlands where dams may be made to catch the waters of wet winters and hold them over for dry ones. Several such enterprises are completed, under way, or projected, and are described by others.

In addition to these large systems there are numerous ways in which water enough for a few hundred or a thousand acres may be had. In almost every valley water may be stored to some extent.

Long, low dams may be made of simple earth as in India. These are quite safe up to about 20 feet without any puddle wall, and can be made by home labor without any engineering skill. In the higher lands there are scores of small streams whose waters may be piped or flumed out. There are hundreds of springs whose waters piped into a cistern and saved will irrigate all the land one needs. Hundreds of others may be tunneled out and the flow of water increased from ten to fifty fold. Water may be pumped or drawn by under-ground pipes from wells sunk in river beds or washes, and horizontal wells may be driven into a thousand hill-sides and reach a fair supply of water where none now shows upon the surface. Artesian water has been found in some places and doubtless exists in more. At San Jacinto there are now eighty-three flowing wells made by boring into old river beds about 150 feet below the present banks of the river.

All over the valley lands water is easily found at from 10 to 40 feet in abundant supply for windmills or other power and nearly all valleys have some wet ground where irrigation is unnecessary for any purpose. The average depth of water in wells is less here than in the East owing to the different formation of the country. Irrigation is also unnecessary on nearly all the highest lands, and on the highest rain belt might be only a detriment for most things. Many of the lowland valleys and slopes do surprisingly well with nothing but good cultivation, especially when the subsoil is clay or red granite, which hold water like sponges. On the lowlands generally irrigation is, however, necessary for some things, and on the mesas is needed for nearly everything except grain which is irrigated nowhere south of the San Joaquin Valley. As a rule whatever can be done without irrigation can be far excelled by it, provided it be not done to excess and be accompanied by thorough cultivation.

It is not always necessary that irrigation be continued all summer. It is not to keep things alive through months of rainless weather that irrigation is needed in California. There is little trouble in doing that. Many things need no irrigation later than June, and many more do well enough with the ground well wet down by the middle of May. In many places where water can not be obtained in summer plenty may be had in winter and spring, and in many others where a summer flow would be too expensive to maintain a winter flow is easily and cheaply secured.

I have made a careful estimate, and place the amount of land irrigable in this county by all systems, of both winter and summer irrigation (except vertical and horizontal wells or tunnels), at about 200,000 acres. This supposes the first cost to be not greater than about $50 an acre. Generally it will not exceed $30 for the first cost with an annual cost of about $4. The amount irrigable by wells and tunnels and small

dams can hardly be estimated at much less than 200,000 acres more as it is solely a question of expense.

PRODUCTION.

San Diego County produces in the highest perfection everything that can be grown in California at all. The great peculiarity of southern California is that it is the only southern land where all the products of the temperate zone reach their highest excellence side by side with those of the tropics. This peculiarity San Diego County has in the highest degree. As in California generally, special soils and elevations are best adapted to special products, and only in certain places do some things reach the highest excellence. But subject to these modifications this county is fully equal, and in some respects superior, to any of the southern counties. A few miles from San Diego grow the finest apples and potatoes in California. Apples, peaches, and plums, fully equal to those of the north, are grown along the lowlands here, but those of the mountains excel those of the coast. The same is the case with all berries and small fruits. Most of these can be grown nearly to perfection on the low lands, but in the mountains all that can stand heavy frosts reach their fullest excellence. Cherries, raspberries, blackberries, gooseberries, currants, strawberries, etc., can all be seen bearing in abundance large fruit of the finest flavor, and without irrigation. The superiority of nearly all deciduous fruits and vegetables grown in these mountains will in time make them extremely valuable. All sorts of fancy fruits grow well; the guavas, the Japanese persimmon, the pomegranate, and others. The almond is not a prolific bearer anywhere in the south, though otherwise a beautiful tree; but the English walnut has done marvelously well at places where it has been tried, while all varieties of fig trees hang full of excellent fruit. The olive thrives almost anywhere on the low lands without care or water, though like the fig and everything else it will do better with both. Peaches also do very well, though those of the mountains are much the best as well as the most prolific.

Fancy trees, bushes, shrubbery, flowers of all varieties, the camphor tree, rubber tree, banana, palms, and a thousand other things, seen only in green-houses in the East, grow here with little or no trouble, though such things as the banana require a place quite free from frost and also from wind.

Most kinds of vegetables grow in winter, and many kinds, such as peas, turnips, onions, beets, cabbage, carrots, cauliflower, then grow the best. The tomato, if planted above the frost belt, becomes a perennial, growing year after year, climbing often over a small house, and bearing the year round. Nowhere else will the same acreage produce such a variety and quantity as on the irrigated lands of southern California. Even where the whole tract can not be irrigated fine results can be secured. Ten acres of land, with the water that an inch and a half pipe will carry from a stream, spring, or ditch, and the work that a successful gardener in the east puts upon 10 acres, will, with 30 acres of dry land outside, not only support a family, but leave more money over than the best 160-acre farm east of the Rocky Mountains. Three acres in alfalfa, well irrigated, will keep two milch cows, a dozen hogs, and a score of chickens the year round with all their increase. Half an acre more will raise all the vegetables a large family can use in a year, while the rest in raisin grapes, fine oranges, or a dozen other varieties of fruits, will yield a fair income. On dry lands outside of this, thorough

plowing without irrigation will raise plenty of the best hay, which is made of grain cut in the dough or milk; also olives, apricots, wine grapes, figs, and many other things that bear well with cultivation alone. Irrigation will of course improve the yield of all such fruits, especially in some years; but very little water is needed, and fair results may be had without any. Many things that are sure to be profitable in the future are very easily raised. The olive, for instance, grows on dry land with very little attention, is a hardy, prolific, and steady bearer, and outlives its owner's family. As soon as enough are grown in the vicinity to supply an oil press the profits are large and constant. Pickled when ripe they form an article of food which the whole family soon learns to like, as substantial as potatoes and infinitely better to the taste than the foreign olives, which are pickled green to preserve a stylish color.

To run through the list of trees, vegetables, grains, and berries that can be grown here, with their special modes of cultivation and their profits, would take a volume. Suffice it to say that about everything can be raised in San Diego county that can be grown in the temperate zone at all, with many of the best products of the tropics. The profits will depend upon the industry, attention, and business capacity of the producer.

Prices of land vary so with locality, rain-fall, and irrigation facilities that it is useless to attempt to give any scales. There is enough to be had from $10 an acre up to $150. There is little held at over $125. Plenty of fine land may yet be had at $50, and in the mountains the surest land in the world for crops may be had for $20 to $40, and even as low as $10 in remote places. This of course is outside Government lands.

CLIMATE.

There is no better test of a desirable climate than the number of days one can spend out of doors. The following record kept during my first winter in California is extraordinary for a country where one can live and raise anything. Yet it was the unusually good season of 1875–'76, when 6,000 acres of wheat in El Cajon, scratched in with a harrow, yielded an average of 20 bushels to the acre, and the honey crop and other crops were immense. The record was kept in El Cajon, to see how many days could be spent out of doors in hunting, etc. From first to last rain, one hundred and fifty-nine days, there were one hundred and twelve days warm and clear. Noon temperature, 65 to 75 degrees. There were thirteen days cloudy but warm; clear and cool, eight days; cloudy and cool, six days. Noon temperature of cool days, 55 to 65 degrees. Rainy all day, ten; showery, ten. The lowest noon temperature was 55 degrees. The days marked "showery" were days of clearing-up showers after rainy nights, and were exactly like "April showers" at the East; days when one could not venture out for a whole day, or perhaps a whole half day, but could still spend one-half the day out of doors. Here were one hundred and thirty-nine out of one hundred and fifty-nine days that one could spend entirely out of doors, and but ten days that one need spend wholly within. And this in a year wetter than two-thirds of the years in all southern California. Of course all the rest of the year one could spend the whole day out of doors.

Leaving the details of settlements and their growth and advantages entirely aside, let me say in conclusion that it has often been said that San Diego County is but a desert. Over half of it is so. So is half of

Los Angeles County and more than three-fourths of San Bernardino County. But upon two things one can rely:

(1) That thousands of wealthy people do not make permanent homes in deserts.

(2) That great railroads do not cross deserts for the sake of making a terminus in another desert.

THE WATER SUPPLY.

Mr. James D. Schuyler, construction engineer of the Sweetwater Dam and Reservoir, while serving as assistant State engineer, made a thorough examination of the water-supply of San Diego County. On that subject he said:

Careful investigation has convinced me that the supply furnished by the rain in the mountains 40 to 60 miles back from the coast, properly husbanded, is ample for all probable necessities. From Temecula south to the Mexican border there are over 1,000 square miles of territory draining seaward, ranging in altitude from 2,500 feet upwards, upon which the observed rain-fall is reported to be never less than 25 inches and often reaches 60 inches. It will be readily admitted that every square mile of this area, therefore, must shed more than sufficient water to irrigate an equal area within the dry belt along the coast, and we may roughly say that the waste water flowing to the sea within this section in the driest years is sufficient to irrigate 500,000 acres of land. Is it practicable to store water in the rainy season to maintain the needed supply throughout the year? Nature has provided great numbers of flat, commodious valleys, with narrow outlets, well adapted to the construction of retaining dams, for which the best of material, solid granite, is generally supplied on the spot. Indeed the entire county is remarkable in this respect. I know of no other section of California containing so many large and capacious sites for reservoirs. Their conversion into artificial lakes is a mere question of cost and engineering skill. A doubt has been frequently raised as to their being made water-tight, and fears have been expressed that the fissures everywhere to be seen in the mountains would swallow up the contents of the reservoirs when filled. The best answer to this objection may be given by referring to the frequent natural ponds and lakes in the mountains. Wherever a valley is level or a slight elevation at its outlet obstructs its drainage, water may be found standing the year round.

As the first irrigation project of any magnitude in the county, the works of the San Diego Flume Company are naturally regarded with special interest. As a type of many similar works that may be carried out successfully in the county, I have given them careful attention, the more so as the surveys, plans, and levelings of the company have given me more exact data to examine than I have had in other sections. Briefly stated, they propose to divert the waters of the San Diego River, at a point 35 miles above San Diego where, at an altitude of 800 feet, all the higher mountain drainage is concentrated, and carry them in an open flume, a distance of nearly 50 miles, to San Diego. The surplus waters of the Upper Sweetwater and Santa Isabel Rivers are to be diverted into the higher tributaries of the San Diego. Reservoirs covering 300 to 1,200 acres are to be constructed to store the winter rains and furnish a summer supply when the streams fail. Three reservoirs are to be immediately constructed, and several others are selected for construction if required. Their flume is projected to carry 5,000 miner's inches of water (100 cubic feet per second). A miner's inch is considered adequate to irrigate 10 acres in orchard or vineyard, and many important districts have to eke out 1 inch to 30 acres. At the former rate the supply to be carried will be adequate for the irrigation of 50,000 acres of land. In Riverside and elsewhere water adds an immediate value to dry land of $100 to $150 per acre. Applying these figures to equally desirable lands in this county, it requires but a simple calculation to establish the disproportionate relations between cost and value of water for irrigation. The feasibility of constructing a flume of this character along the mountain sides for such a distance can not be questioned. There are too many precedents to such works to raise a doubt on that score. The loss of water by evaporation will not exceed one-half of 1 per cent. of the maximum flow, and leakage may be reduced to a small amount by careful construction and calking seams.

Comparing this county with other sections of the State, I have noticed several advantages favoring irrigation development, aside from the one mentioned of a remarkable number of storage reservoir sites, viz, the general freedom of the higher mountain streams from sand and fine débris that would tend to fill up and destroy reservoirs, and the absence of landslides that are so much to be dreaded. The soft granite may *be cut* vertically, and stands for years without a slip or slide into the excavation.

CALIFORNIA PAPERS RECEIVED BY THE COMMITTEE.

STATEMENT OF JOSEPH DUNBAVARD, OF LIVERMORE, IN RELATION TO "GANG" OR "DRIVEN" AND ARTESIAN WELLS.

My opportunity for forming an opinion of drive wells and artesian wells has been by a residence of nearly three years in Florida, also in Brooklyn, N. Y., Vineland, N. J., and other places. But principally I have acquired knowledge concerning them during the time I was editor of a newspaper at Eustis, Fla., called the Florida New Yorker, at which time I entered into correspondence with various parties—with Geo. H. Clark, then postmaster at Daytona, Fla.; with Henry A. Harrison, manufacturer, Newburg, N. Y., and also with Andrews Bros., the proprietors of the Brooklyn water works or drive wells. I desire to present these points: Artesian and drive wells I consider essentially the same in principle and action, differing only in size and in this, that the drive well, being of smaller diameter, is *driven* into the ground, hence its name. The artesian well being larger can not be so driven.

As the two kinds of wells differ only in size, as a result of this difference the smaller or drive well brings up water sooner or from a less depth than the larger or artesian well can.

That it really is a matter of dynamics—the smaller well bringing up water sooner because of the lesser weight to be lifted.

That in the arid regions of California and elsewhere drive wells, or gang drive wells could, without a doubt, be put down in numberless situations, and water be drawn up to and above the surface.

That the fact of the surface being dry is no argument against the probability of water being underneath.

That it is rather a presumption that the repulsive force would there be stronger and the water abundant.

That in situations where rocky strata intervene to prevent drive wells being put down borings of small diameter can be made to suit the smaller pipes.

My leading point is a refutation of the prevalent idea of a head of water being required to make water rise in artesian wells. That a head of water will make water rise, if contained in a pipe, is a matter of every-day experience. Thus, let Fig. 1 represent a pipe, and water being poured into the smaller end at A it rises to the same level in the larger end:

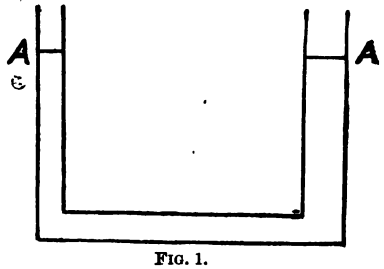


FIG. 1.

This is an axiom, and at once admitted. But it must be remembered the water is in a pipe that is watertight. In the underground geological arrangement there is no such thing as a pipe, nor any resemblance to one. If we take the same figure and dislocate it it will then have somewhat of a resemblance to geological strata, but it will be seen at once the conditions of the first-represented figure are entirely changed, and water would not ascend at all, either to the level of its head, or to any other point:

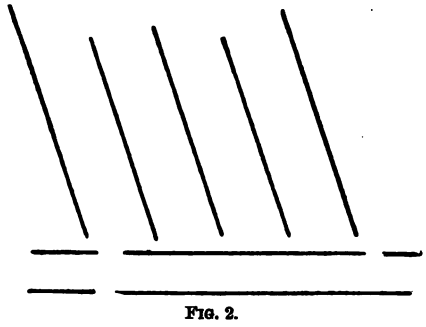


FIG. 2.

And yet such is nearly a correct representation of geological strata. There is absolutely not the least foundation for this "head of water" theory in any arrange-

ment of the earth's strata. If there were such an abnormal stratification as would form something like a bent pipe, of course the water in that case would act precisely as in the artificial pipe; but it can not be found.

If this theory were correct, everything would be in confusion, and Heaven's first law, that of order and harmony, would be set at naught. On the low lands the water would be everywhere bursting up from the "heads" of water on the high lands, and we should have nothing but disruption of the pent-up waters in every direction.

A large part of the rains which fall must necessarily be carried away by the underground courses and traverse towards the oceans, the same as the rivers do on the surface. If we consider the quantity of rain that falls on the earth annually, we shall see how little comparatively finds its way to the sea by the river courses. From 12 to 50 or 60 inches falls annually. In the tropics perhaps it averages 100 inches. By this is meant that the whole face of the land would be covered to that depth, supposing it were retained as on a dead level upon a retentive surface. If all this water were passed off by the rivers they would be filled to overflowing after every shower, and we should have Mississippis and Marañons in every direction. But these things are differently arranged; a large part of every shower passes into the soil, where it is absorbed and retained; but a still greater part sinks into the strata beneath, through the various laminæ, fissures, and faults, through caverns, and still onwards, much the same as on the surface. When it gets still deeper, the repulsive force keeps it up, saying, Thus far, but no farther.

When these great depths are penetrated artificially by a "boring" or perpendicular shaft, the water is thrown up to the surface, and in many cases high above it. If the boring is large, like the Paris well, which is over 3 feet in diameter, the earth has to be penetrated or bored so much the deeper to attain the high pressure necessary to lift such an immense bulk. At, say, 5,000 feet of depth, the eruptive force becomes volcanic in its strength, and the pent waters are thrown upwards with Titanic power.

It must not be inferred, however, that this force acts only at great depths. It commences at the surface, where it shows itself in the form of what is called capillary attraction, as in the illustration:

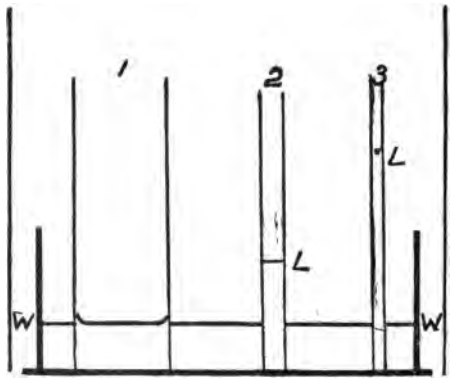


FIG. 3.

No experiments have yet been made with pipes of very small bore. But if the principles here enunciated are correct, pipes of half-inch bore, or less, would be quite practicable. Half-inch bore pumps are not uncommon. A pipe of half-inch bore, but retaining the same outside circumference as the one inch, would be likely to bring up a stream of water above the surface at 30 to 40 feet depth.

In plowed fields, where the surface is made fine, the water or moisture is forced upwards from below by this ever-acting power (of capillary attraction) during our rainless summer. As attraction diminishes with the square of the distance, so repulsion—the counter of attraction—increases as the square of the depth. At 100 feet depth it has little or no effect on a 6-inch well, but at from 400 to 500 feet the water begins to move upward. In a well of 1 square inch, according to an approximate calculation, the water begins to lift at 70 or 80 feet. In a well of 2 inches square the water begins to move at 140 to 150 feet. These calculations are made in square, not cylindrical inches. The unit from which calculations are made is 1 inch. In calculating for 2 inches the weight of water is multiplied by 4, the repulsive force by 2. The weight increases as the area, the repulsive force with the increase of circumference of pipe.

At this point I give a table of reference. As this paper advocates only wells from 1 to 2 inches diameter, which need not go more than 150 feet deep as a general rule, I do not extend the table beyond that point:

Table of reference.

Weight of water.	Depth.	Square of depth.	Repulsive force.
Pounds.	*Feet.*		*Lbs. Oz.*
4.3280	10	100	10
8.6560	20	400	2 08
12.9840	30	900	5 10
17.3120	40	1,600	10
21.6400	50	2,500	15 10
25.9680	60	3,600	22 08
*30.2860	*70	4,900	*30 10
*34.6240	80	6,400	40
38.9520	90	8,100	50 10
43.2800	100	10,000	62 08
47.6080	110	12,100	75 10
51.9360	120	14,400	90
56.2640	130	16,900	105 10
†60.5920	†140	19,600	†122 08
64.9200	150	22,500	140 10

* At the depth of 70 feet the repulsive force balances the weight of water in pipe, the area being equal to 1 square inch.

† At this point a pipe equal to 2 inches square, the water is balanced by the repulsive force. In this case the weight of water as given has to be multiplied by four, and the repulsive force by 2, which gives weight 243, repulsive force 245. Any other size of pipe may be calculated in the same way by multiplying the first column by the increase in area and the last column by increase in circumference of pipe. In pipes of less than one inch bore the figures have to be reduced accordingly.

Yet another consideration in favor of the repulsive force: If we suppose a column of water of, say, 400 feet deep by 6 inches diameter, the weight per square inch would be 173 pounds, or 6,228 pounds on the six inches square. Now is it possible that any rock, much less earth, could long resist such a pressure? Here is a weight of 3¼ tons of water on a space of six inches square. It would, undoubtedly, disintegrate the rock or earth, and force its way either straight down or sideways, and disappear from the pipe in double quick time; but the repulsive force comes in and holds the water, as it were, in the palm of its hand. As soon as the water begins to move upwards a vacuum must be formed beneath the pipe; or rather a tendency to form a vacuum, for a vacuum itself is impossible, and the water must be drawn straight upwards, and a stream started from the internal reservoirs which never fails. Here is a solution of the question of perpetual motion, for the stream once in motion furnishes a perpetual motor.

To the perplexity of well-borers they often find the water disappear in the progress of the well downwards. The truth is, the column of water becomes too heavy to be retained in the boring, and it presses itself downwards and disappears. But when the point is attained where the repulsive force comes into effective operation, the water stays and gradually rises with the increasing depth of well.

This matter of drawing the water upwards is of incalculable importance. A true artesian well, below the surface drainage, drawing the water upwards, does not affect neighboring wells, which retain their usual amount of water. In the alkali countries the layer of alkali can be pierced and good water brought from beneath. The water from a moderate depth, but below the surface drainage, invariably brings up good water.

PUBLIC OWNERSHIP AND CONTROL OF THE WATER THE ONLY SAFETY FOR THE IRRIGATOR.

[Paper forwarded to the committee by ex-State Senator John M. Day, of California.]

The question of irrigation is the most important now prominently before the people of the United States. It has been considered by State legislatures, constitutional conventions, and other gatherings; and the Congress of the United States has at various times appointed commissions to inquire into it. It is most important because it relates to the people's right to the use of a natural element essential to man's existence. No writer of intelligence has ever had the temerity to proclaim that there could be such a thing as private property in running water, and yet I question if

every inch of navigable water in the now navigable rivers, streams, rivulets, streamlets, creeks, and other courses in California is not claimed as private property many times over by water and land grabbers and speculators. In the single instance of King's River, which, according to the ex-State engineer, William Hammond Hall, there were appropriated 24,000 cubic feet, while the records show an average of only 1,730 cubic feet. It is true the law of appropriation which gives this private property says water may be appropriated for beneficial uses, but when once the appropriator appropriates the water, unless he is some poor fellow without means or brass, he construes the meaning of the words "beneficial uses" to be for his benefit, and no government that I have read of has ever had the power to enforce any other interpretation thereof. This is not peculiar to California and the United States, but is the history of irrigation the world over.

During the Senate committee's visit to California all the testimony taken was chiefly about the benefit of irrigation. The benefits of irrigation are incalculable. We have millions of acres of lands in California that will not grow a blade of grass without irrigation, but with irrigation will grow two crops, and in cases of alfalfa and other grasses, for hay, four crops each year. The two important sets of questions to us are, "Does your district need irrigation?" and "Which would be the best mode to benefit your district and the people thereof?"

Any public inquiry into irrigation should inform itself from the history of other countries what would be the best mode in this, so as to protect the rights of every citizen to a use in the water necessary to secure crops. It should be able to propose means to Congress to prevent the plunder of a neighbor. The principle applied to irrigation should be such as to insure a settler the use of water without having to apply to and pay exorbitant charges to private individuals, or having to mortgage his home to the district or any other bondholder. In my study of the question I can see only one way of accomplishing that, and that is by governmental ownership and control.

In California we have three general laws regulating the use of water; the common law in favor of riparian rights, the code in favor of private property through appropriation, and the district law, originally passed in 1872, but a dead letter until amended in 1887, and known as the "Wright bill." Without going into particulars, the common law gives the land owner on the banks of a stream the right to an undiminished flow of the water in the stream minus what may be used by riparian owners above him, its use for domestic purposes and for irrigation, provided he returns what he does not use to the stream. It requires no formula to become a riparian owner. The law of appropriation requires the appropriator to go through a formula. He goes to the bank of the river, or stream, writes on a piece of paper that he has appropriated so many inches or feet of water, puts the paper on a bush or other place as a notice to others, records his appropriation within ten days at the county seat, and commences operations in ninety days to construct head or other works. There is no limit to the amount a man or corporation may appropriate or claim; ten times the average amount the river carries has been appropriated. The district law provides for the land-holders of a district to organize, elect trustees, assess the cost, issue bonds, condemn water rights, and sell out the land-holder for delinquent assessments. The latter law seems now to be in favor and may work for a time without much apparent injury, but there is no doubt in my mind that before many years elapse many a poor land-holder will have to succumb and give up his land to the bondholder.

For several years last past, in California, there has been a fierce war waging between the riparianists and rich appropriators, which finally culminated in a decision of the supreme court in favor of vested rights, and a special session of the legislature, intended to turn out the supreme court members and change the law, and induce candidates for the new supreme bench into agreeing to reconsider the decision in favor of vested rights, and decide the appropriators to be the exclusive owners of the water. The decision of the supreme court of California in a nut-shell is: If the riparian owner settles on the banks of the river before the water above him is appropriated according to law, he acquires a vested right which he can not be deprived of, except by payment for his so-acquired right. If the appropriator first takes his appropriation he has the same vested right.

The origin of the fight is the desert land act, signed March 3, 1877. Under its provision in four years, 897,160 acres were taken up. In the county of Kern, thousands upon thousands of acres were said to be taken up by dummies, and transferred to other parties in bulk. Years before this, however, another land firm became the owners according to law of immense numbers of acres of land, and acquired, through the common law, riparian rights.

There were many appropriators in the valley but no conflict, until the second party claimed nearly the whole of the water in Kern River by direct appropriation and the absorption of the small appropriators. After the supreme court had decided the fight in favor of vested rights, the question was taken to the legislature. Failing there during one or two sessions, a special session of the legislature was called to

pass bills in the interest of the appropriators. A fierce public agitation was aroused. This was the condition of things when, on the 20th of July, 1886, at the call of the governor of the State, I took my seat in the State senate. During the first week of the session advance copies of a magazine article on irrigation, from the pen of the late A. A. Sargent, were distributed. The article quoted the history of irrigation, and to a person who had not read about the subject, appropriation was the only mode of water-use that had ever been established with success.

A great deal of the ex-Senator's article is about Italy. He says: "The length of canals in Lombardy alone is over 5,000 miles, and there is scarcely an acre of the Milanese that is without several intersecting canals. In round numbers there are a million acres irrigated in Lombardy. The system has been perfecting for seven hundred years, and has gone on under all changes of dynasty and all civil commotions. It has converted a barren waste into a garden. * * * In exercising its right of property in waters available for irrigation, the government of Lombardy follows one of three courses: First, it disposes of the water in absolute property, to parties paying certain established sums for the right to divert it; second, it grants perpetual leases of the water on payment of a certain annual amount; third, it grants a temporary lease for a variable time at a certain annual rate, the water reverting to the State on the termination of the lease. By far the most common of these courses is the first, and it operates the most beneficially."

The whole of this quotation is taken from Baird Smith's Irrigation in Italy. The fault I find is in garbling the last sentence, which reads: "By far the most common of these courses is the first; *and it has, on the whole, I think, operated beneficially in the actual circumstances of the country.*"

Captain Smith lays great stress upon the statement just quoted, and goes on in pages 136 to 140 of his work to explain it at great length.

I propose to show from the writings of Mr. Hall, the ex-State engineer of California, and others, that although the rivers of Italy have been considered public property for seven hundred years, the Government has never been able to regulate them after granting the *use* in perpetuity, which is not so strong a term as we use—appropriation. On page 258 of Hall's "Irrigation Development," in speaking of the conflict between appropriators and irrigators in Italy, he says: "In Italy, as in irrigating countries generally, where there has been a clashing of interests between the owners of canals or holders of great water privileges and the irrigators to whom the waters were to be distributed, special points came up in this connection. Many water rights were established there by grant and prescription, in times when from a troubled condition of society no thought was had of future agricultural masses of people with interests to be protected. A water right aristocracy grew up, the canal owners claimed the absolute property in the water held by them and undertook to do with it what they chose."

M. Giovanetti, an Italian lawyer, quoted by Captain Smith (page 134), says: "It appears to me that it was not for purposes of police that the feudal superiors exercised all the rights of masters over the various water courses, but that their right of *absolute property* necessarily absorbed everything previously held to belong to the community. There existed in fact merely the relations of masters and subjects." He further says, on page 148: "I find that the waters of the Olona River were granted to the Cistercian Monks, of Charavalle; were in the twelfth century claimed by a society of Employers (Utenti) of the Olona, and from time to time it raised claims to entire independence of the administrative authority of the State, on the grounds that its right of property in the stream was absolute." On pages 198 and 199 I find that the proprietors of the streams on the borders of two countries were so in conflict, one with the other, that in spite of edicts passed by the General Government in 1602, 1603, 1607, and 1610, and of all efforts made to settle the difficulties, the two countries were nearly embroiled in war. The power of the appropriator for evil is seen in the following. I quote from page 257:

"In 1832 the Marquis of St. G., farmer of the canals of the Vercellese, having quarreled with his neighbor, the Marquis Pal, persisted during eight consecutive years in throwing into the river Po two route (about 24 cubic feet per second) of water, for which the Marquis Pal offered to pay him 12,000 francs a year. * * * This same Marquis St. G., wishing to force the commune of T. to submit to an arrangement which it regarded as oppressive, refused to allow the surplus waters of his vast domains to flow into the land of this district, although he was offered 6,000 francs a year for them. He preferred throwing them for two years into the Po, to his own loss and to the injury of his neighbors."

This illustrates one of the beauties of private property in water. 'Tis true the law finally interfered and compelled the Marquis to sell his surplus water instead of wasting it.

It is asserted that the State can regulate the use of water even when appropriated. I quote again from Captain Smith: "The holders of ancient grants in perpetuity have occasionally asserted an absolute right of property in the water thus granted to

them; but the legal tribunals have invariably rejected such claims, on the ground that the grants were made for the general good of the country as much as the special advantage of the grantees. The large canals, Mora, Busca, and Buaga, derived from the Sesia, have been held by grantees since the close of the fifteenth century. On these works a very large portion of the irrigated land of the province of Novara is dependent, and the outlets are held under annual leases continually renewed. Farther to the southward, in the district of Lumellina, water is less abundant, and therefore bears a considerably higher value. This latter fact led the grantees of the canal Mora to attempt, about the close of the last century, to discontinue the supplies which have been furnished for centuries to a number of proprietors near the head of the canal, with the view of carrying the water thus obtained to the southward and there renting it at higher rates. To this project very decided opposition was naturally enough offered by the parties whom it was thus proposed to ruin. * * * The case was carried before the senate of Turin, which by a decree under date April 13, 1787, decided that the proprietors of the canal should continue to give to the employers of the waters those volumes which they and their forefathers had so long enjoyed pending the further investigation of the case; and the employers were called upon to submit evidence in support of the reasons on which their opposition was founded. The suit was, however, pursued no further, the grantees of the canal abandoned their design, and the employers continued to enjoy their ordinary supplies of water at the present day. * * *

"The temporary effect of these decisions was to create an impression that no employer holding a term lease of an outlet of irrigation could be deprived of it so long as he paid the price for the water. Subsequent decrees of the court, however, showed that unless such outlets had been held for long periods, had been established and maintained during these periods at considerable expense, had been accompanied by other agricultural works, and that no special agreement to the contrary existed between the proprietor of the canal and the lessee of the water, temporary leases were revocable at the will of the former. M. Giovanetti mentions that he proposed to the commission on the civil code to define and establish the principle involved in the decisions of the courts above referred to, and that it was accordingly introduced into the first draught of the code. The senates of Nice, Savoy, and Turin approved the principle, only altering the terms of expression; but the chamber of accounts and the senate of Genoa demanded its suppression as incompatible with the right of property. The commission on the code adopted the latter view, and the two articles defining the right were accordingly struck out."

This, I believe, is the final adjudication of the question in Italy. This is a flat refutation of the position assumed by Engineer Hall and the appropriators. For seven hundred years the waters of Italy have been said to be the property of the government to regulate, etc., and during seven hundred years trial to regulate the waters and the appropriating holders in perpetuity has gone on continually. The highest power in that land has declared that to regulate and interfere in the interest of the irrigator is to interfere with the rights of property.

This, however, is only one of the phases of irrigation, for it is not simply a question of who shall own the water and apply it to the land. It is a more complex problem. It includes water storage by reservoirs and forestry; the proper building of head works and ditches in relation to safety and health; a just and proper distribution of water for the benefit of all concerned; the most consummate hydraulic engineering, and intelligent, thoughtful, and deeply studied legislative enactments in the interest of the people of the whole state. One of the effects of the system of appropriation is, the water being frequently appropriated for speculative purposes, and the appropriator caring for nothing but the profits from the sale of water, waste follows, and malaria and other diseases are the consequence.

Colonel Alexander, Major Mendell, and Professor Davidson, of the Coast Survey, were a commission appointed by the United States Government in 1873 to examine the San Joaquin Valley as to its possible reclamation. In their report they say "the profession of the hydraulic engineer for agricultural purposes is almost unknown, and the farmers, as a general thing, do not understand how to use the water when it is delivered alongside their lands.' Continuing, this commission pointed out canals and places by name, and showed that the places were unhealthy because of the canals being improperly built. But this is the history of private ownership of water for irrigation all over the world. The private appropriator cares only for what he can make out of the water at the least cost to himself, irrespective of the influence of his mode of doing it. If we contrast that with the care taken by the Government of the irrigation districts in India in examining into the condition of the people as to their health, it will be seen at once that it is in the interest of all the people that the system of irrigation should be under the ownership and control of the people in their collective capacity; in other words, of the Government.

In the fourteenth century the canals of India were beautified by the planting of *shade and fruit* trees, and everything was made pleasing and profitable. The British

Government has within the present century taken up the matter and appointed commissioners to take charge of this part of irrigation, and beside the great benfit accruing to the country, the cost is estimated at about one-fourth of the income. How much better would it be for everybody in the United States to have a proper system, than allow these things to go on slip-shod fashion as they are going on here. Every man, woman, and child in the country is interested in having a proper system established, not alone because it will give them better and cheaper food, but because it will affect the health and well-being of the nation for good. In India, under government ownership and control, the cost of maintaining the works is 14 cents per acre, the original cost about 60 cents, while the original cost in private property appropriating Italy is upwards of $74 per acre; while the cost to the irrigator is upwards of sixty times greater in Italy than in India in the same class of works. In Spain, where the water is private property, immense sums of money are paid by the users; on one occasion according to Engineer Hall, $11,000 was paid for 1 cubic foot per second for twenty-four hours. Where the system has been handed down from the Moors the cost is merely nominal. This is because it is controlled by the community. In France many peasant proprietors are too poor to purchase water for irrigating, and where the works are the property of private individuals the rivers are unfit for use in many places, owing to the neglect of the proprietors, while the reverse is the case where the Government owns the head works.

As a member of the State Senate and of an investigating committee appointed by it, I arrived at Bakersfield, the county seat of Kern County, late at night, on the 28th day of August, 1886, with the intention of going over the ground made so famous in the controversy between the riparianists and appropriators. On the following day I saw many of the fields made fruitful by irrigation; immense alfalfa and stock ranches, horses, cattle, sheep, ditches, etc. On the 30th Messrs. Chandler, Steele, Whitney, and Cross, State senators, also arrived, and we were taken to view the grounds of Miller and Lux, a distance of about 24 miles from Bakersfield. We lunched at their headquarters, and then were driven miles over the grounds. We looked in vain for any signs of the water in the river which made them riparian owners. 'Tis true we saw a channel for water to run in, but no water. As near as we could tell, we rode about 20 miles over ground claimed by Messrs. Haggin and Carr. I don't remember seeing a school-house the entire way, and, in fact, very few houses of any kind. We returned to Bakersfield about 9.30 p. m. On our arrival we found a great commotion. The appropriators were out in full force.

The small farmers were also in force and desired to talk over the situation with us. This congregation of farmers were all owners of shares in ditches, but opposed to the appropriation monopoly. The next morning we were taken by three of the farmers for a birds'-eye view of the valley, and also to see the celebrated Calloway Canal. This is the largest irrigating canal in California, being 120 feet wide at its mouth. We found the Calloway empty, and were informed the water had been shut off. Before taking this trip several farmers again called upon us. I was the only one present. I saw three other senators, and by their consent I made an agreement for all to meet the citizens that night, listen to their grievances, and talk the matter over with them as to the best mode of finally settling the irrigation question. An effort was made to retain us over night at one of the ranch mansions. I demurred to this on the ground that we had agreed to meet the citizens. I intended to keep my word, and, as I was obstinate, they promised to bring me back at the stated time.

We were then driven rapidly through the country; saw irrigated fields of alfalfa, many hay-stacks, cattle, horses, sheep, a few turkey-buzzards, occasionally a building, and one school-house. I eyed the school-house for a long time to see if there was any life near, but I saw none, although it seemed to have been newly painted. We were driven into an alfalfa field of about 700 acres, belonging to a banker, in which was one shanty. Several hay-stacks, some sheep, and one sheep-herder were the residents of this immense field. We were at last driven to Belle View, the principal ranch of the principal appropriator in California, where I left my brother senators to eat turkey and to be further instructed into the mystery of legislating all the waters of the State into the pockets of the appropriators. At Bakersville I found quite a number of farmers waiting to meet the senators. I passed a couple of hours in their company listening to their story. On the next day I rode over a deal of ground with John Barker, editor of the Echo, published in Bakersfield. We passed over a good site for a reservoir for the storage of water, which he considered would by an outlay of about $5,000 be made to store enough water to irrigate 70,000 acres of land. He also informed me that at a place some miles above a storage for an immense amount of water could be obtained by buying out two ranches.

Mr. Barker was thoroughly able to give information on the matter, as he had surveyed the head of the valley in every conceivable way, with reference to a thorough knowledge of the utilization of the waters for the benefit of irrigation.

On my return I again found a large number of farmers patiently waiting for the senators. But they were doomed once more to disappointment, for they were informed

that the banker was to entertain them at dinner. These men who had so very patiently waited four days, some of them coming a distance of 20 miles, naturally felt angry. They hired a hall and held a meeting and at half past 9 o'clock the five senators took their seats on the platform, and, after a speech by the chairman, resolutions were unanimously adopted condemning the principle of appropriation as conducted by Haggin and Carr. The following facts I gleaned at the meeting and during my interview with the farmers:

When this firm entered the valley they found a large number of small ditch-owners and prevailed upon them to put their ditches into corporations, etc. The corporations were organized, larger ditches were built, and in every instance the new comers had a majority of stock, elected their own officers, and have run the entire concern. Many of these men were deprived of water while it was supplied to Chinese tenants. Mr. Randall testified at the public meeting that when he wanted water it was frequently turned out of the ditch to prevent him using it. Seventeen of the farmers present at that meeting verified his statement in letters to the senators when they returned to the State capital, both as to his and their cases, all being owners in ditches similarly situated.

The average school attendance had dwindled down from 649 in the year 1880 to 246 in 1886; and this is the effect of private property in water.

One farmer had settled in Kern County years before the appropriator had ever dreamed of going there, had paid the Government for his land; a natural water-course ran through the land from which he irrigated and made a good living. The appropriator claimed to have appropriated the water, forbid Mr. Judd's using it even when it was running to waste upon the desert, and finally turned it off from his land altogether.

The school district of San Emigdio is not subject to irrigation from the river. It is a portion of an old Spanish grant, and a few families had lived there many years. A spring supplied them with irrigation. The spring was confiscated under the law of appropriation, and the water diverted to beneficial uses in a ditch past their lands. Offers were made to buy them out. These poor Mexican farmers refused. Here they had raised their families; here was the only world they knew; here they wanted to stay. The little seepage water which was allowed to escape the large ditches would do service in the support of their families. For the purpose of freezing them out cement was used to prevent even a drop of water escaping on to their lands, and the poor farmers succumbed, while the school with its average attendance of twenty-six children collapsed. The land passed into the canal owners' possession. Under our law of appropriation, then, one firm in Kern County owns a strip of land 75 miles long, which in many places is 30 miles wide; that upon 49,903 acres of land they are assessed at a land valuation of 25 cents per acre; that 15,000 acres are growing alfalfa and wheat, while other crops could be raised to make the county rich. This course has depopulated the county and shut up the schools. It is time to cry halt to this system of private property in natural waters and demand that all waters for irrigation purposes shall be under the ownership and control of the Government.

In conclusion, let me contrast this state of things in Kern County, Cal., with the following facts which occurred in India, where the waters for irrigation is owned and controlled by the Government:

In 1820, when the British got control of the district of Mairwara, the inhabitants had been freebooters for centuries, had been notorious for their depredations, and robbery was the profession of the whole race. Each district in Mairwara had its assigned field for plunder in the adjoining lowlands. The horsemen in small parties haunted the highways, looking out for marriage cavalcades and pilgrims bound for the shrines of Rajpootana. When Ajmeer fell into the hands of the British it was not safe for an unarmed man to be outside the walls after sunset. Repeated attempts to subjugate them were made by the larger states of Rajpootana. The efforts were unsuccessful, and not only emboldened the freebooters but encouraged them to levy revenue from other districts. They were eventually conquered by British soldiers, divided into three sections, and placed under three separate governments, where they were supposed to be in such a minority that they could easily be kept in subjection; but such was the desperate character of these people that they would have subjugated the native governments under which they were placed, had it not been for the superior force of the British. Then, under the control of a British captain, they were collected again on their own lands. With assistance from the Government, they commenced anew as tillers of the soil. They were assisted with provisions, implements of labor, canals and ditches were dug, and every means provided to give them a fair start.

Baird Smith says (page 410 vol. 1) in his Italian Irrigation: "The village [villages] was formally inaugurated, and remissions in rent were granted until the hamlet was considered sufficiently advanced to bear the usual rates. During the first year, one-sixth of the produce was taken as the government share; during the second year, one-*fifth;* and during the next four years, one-fourth. After that period the rates were *the same* as in old villages. At the same time the settlers were furnished with ad-

vances of money for the purchase of bullocks, and for the construction of small works. These advances were repaid in four or six installments, within three years after the establishment of the village. Tools were furnished free to all who needed them, but the settlers were expected to build their own houses."

From this time to the time Captain Baird Smith published his book, a period of about thirty years, no complaint had ever been made against them. In fact, they became a model for industry, probity, and honesty. Such was the effect of their contentment and prosperity that the peasants of the adjoining provinces of Ajmeer and Rajpootana began to emigrate to Mairwara. The chiefs of these provinces wrote to the chief of Mairwara protesting against the loss of their subjects, who replied that they must do something to better the condition of their own peasantry. The chiefs took the hint, made the desired improvements, and were blessed by the return of their people. It was not many years after they had established themselves in their new pursuits that they were called to assume the defense, not only of themselves, but of their neighbors. And we find the same good offices which converted them from pestilential robbers to honest tillers of the soil again put in requisition, again by the same man, and again with the same effect. The following account I take from Baird Smith (page 338, vol. 1), slightly changing the language:

In 1836, a gang of robbers from Marwar having plundered the town of Gungapoor, in Mewar, in returning with their booty though British Mairwara, were attacked by the villagers, who in their new character as cultivators had suffered from the depredations of the gang. Twelve of the gang were killed and twenty-nine made prisoners. These were confined in the Mairwara jail under sentence for four years, but before the expiration of this period a plan was suggested for converting these men, whom poverty and ignorance had made robbers, into thrifty and useful subjects. A portion of the uncultivated land some miles from the jail at Nya Nuggur was assigned to them. The prisoners were permitted to quit their confinement every morning, partially unfettered, for the purpose of digging wells at the new settlement, returning every evening unattended to sleep at the jail. On the expiration of their sentence they were joined by their families and relatives and commenced in earnest on the cultivation of the soil. A year after their release the new village exhibited signs of prosperity. It soon contained twenty-seven families and paid a yearly revenue of £77 sterling. From the day of their location no charge of misconduct had been brought against them up to the time Captain Smith published his book. The character of the people has been marked by order, propriety and untiring diligence.

Captain Smith further says: "The scope and success of Colonel Dixon's measures have been sufficiently indicated in the preceding pages. Though much was done by his predecessor for the the civilization of the Mairs, yet undoubtedly all this was most precarious whiile their subsistence and employment were dependent on most uncertain seasons, and the development of a great system of irrigation works (by which the fallen rain is economized to the utmost, and distributed in time and place of need, instead of sweeping down the valleys and passing away in a useless torrent) has been the means of giving permanence and advancement to the improvement in the character and habits of the people."

For the reasons set forth in the foregoing statement I would earnestly recommend that in whatever may be done by the United States Government to assist the irrigators of the various States in the way of irrigation, that every right be reserved; and that no power to "appropriate," even the use of water be given. History shows that if the appropriation of even "the use" be granted, the apropriators will in time set the Government and the people at defiance. And I further urge that if any sites for storage, or forestry, or other water privileges be granted to any State, the right of revocation should be reserved to the General Government to be applied, if said State should alienate the grant on any ground whatever.

ARIZONA DIVISION.

YUMA, ARIZONA, *September* 4, 1889.

The committee met pursuant to the call of the Chairman.

Present, Messrs. Stewart (chairman) and Reagan; also, Director Powell.

STATEMENT OF H. W. BLAISDELL, OF YUMA.

The CHAIRMAN. What is your profession?

Mr. BLAISDELL. I have a ranch of 25 acres in fruit 9 miles east of this town.

The CHAIRMAN. Near the railroad?

Mr. BLAISDELL. Yes.

The CHAIRMAN. When did you commence to cultivate your ranch?

Mr. BLAISDELL. About the 1st of January last I commenced to break ground, and late in January I commenced setting out my trees and vines. They were all set out later than they should have been owing to delay in starting. What I have to show you here are the results of eight months only.

The CHAIRMAN. Describe the result?

Mr. BLAISDELL. The peach trees have grown from small stems to an inch and a half in diameter. But a growth of 3½ and 4 feet of grape-vines have grown 6 and 8 feet. Orange trees have made a heavy growth, and figs are growing well.

The CHAIRMAN. Have you planted any dates?

Mr. BLAISDELL. I have no dates set out. We have had them in this place fourteen years, about 8 miles below the city.

The CHAIRMAN. How do they prosper?

Mr. BLAISDELL. Very well; scarcely anything grows better. The trees are 25 feet high and 2 feet in diameter, the result of four years' growth. The limbs fall down as they increase in years, as the date that you see in tropical climates.

Senator REAGAN. Do you raise enough dates to send to market?

Mr. BLAISDELL. Hardly, yet. Our home consumption would exceed the production.

The CHAIRMAN. Can you produce dates generally throughout the Territory?

Mr. BLAISDELL. Yes. It is the natural wild date that grows here.

The CHAIRMAN. What variety of citrous fruits can be raised here?

Mr. BLAISDELL. The lemon, the lime, and the orange do exceedingly well here, especially the lemon and the lime. They ripen very soon, two months earlier than they do in California. We have no early oranges here; so we can not say what time they will ripen. We have them growing, but not bearing yet.

The CHAIRMAN. What are the facilities here for irrigating this land?

Mr. BLAISDELL. We have abundant water supply in the winter and *spring*, up to about the 1st of June.

Senator REAGAN. Without irrigation?

Mr. BLAISDELL. No, we have no rain here to speak of. The rain-fall being about 2½ inches, practically amounts to nothing. We have in the Gila River an abundance of water up to the 1st of June. It varies according to the position of the county, the upper part having more water than the lower part.

The CHAIRMAN. In the upper part they take it out first?

Mr. BLAISDELL. Yes.

The CHAIRMAN. Is there enough water in the Gila River to provide all that you want?

Mr. BLAISDELL. In the winter the stream is wide, and something like 4 feet deep. We can fill almost any reservoir that you can build. The evaporation, by the report of the Signal Service, is one-third of an inch a day for the three summer months, an average of 10 inches for the three summer months. They made a survey for the reservoir site, and allowed for an evaporation of 7 feet—over half an inch a day for the whole year; and, making that allowance, we have a storage capacity with a flow of 150,000 inches for six months in addition to the natural flow of the river during the summer.

The CHAIRMAN. Have you near here a good site for a reservoir?

Mr. BLAISDELL. Yes; we have an excellent site about 80 miles east of this place.

The CHAIRMAN. Then you think in the Gila River there is plenty of water that could be stored?

Mr. BLAISDELL. In the winter-time and the spring we have the freshets. That covers a large part of the bottoms.

The CHAIRMAN. When you do have rainy seasons what time in the year are they?

Mr. BLAISDELL. Generally in the winter. We generally have no rain in the summer. Rain is the exception in the summer.

The CHAIRMAN. Further east from here they have rain in the summer?

Mr. BLAISDELL. Yes, at the ranch we occasionally get some; but it is the exception.

The CHAIRMAN. What area of country have you in the vicinity of Yuma that could be irrigated if you stored your water?

Mr. BLAISDELL. About 600,000 acres of land below the reservoir.

The CHAIRMAN. Is the reservoir site on public land?

Mr. BLAISDELL. Yes. There are two cattle ranches located on the reservoir site, but no filings have been obtained. The dam would be required to be 100 feet high to flood an area of 48½ square miles.

The CHAIRMAN. How large would your reservoir site be?

Mr. BLAISDELL. Forty-eight and one-half square miles. It flows back about 24 miles. The average depth we estimate to be 35 feet, allowing for evaporation. I think the capacity will exceed our estimates at least 25 per cent., because we have made no estimate of the cañons.

The CHAIRMAN. What crops do you produce, taking the winter irrigation that you have in the flood-time?

Mr. BLAISDELL. Barley, wheat, hay, and all kinds of sugar-beet can be produced here. You will find that this will, in all probability, be the sugar-beet country. There is 17 per cent. of sugar in our beets, and it is estimated that the yield from properly cultivated beets will be over 20 per cent.

The CHAIRMAN. How do the laborers in this climate stand working in the sun? This country has the reputation of being a very hot one.

Mr. BLAISDELL. Our extreme heat this summer was 117 or 118, but it is equivalent to 88 or 90 only, taking moisture into consideration.

The CHAIRMAN. It is equivalent to a temperature of 88 or 90 degrees in New York or Washington?

Mr. BLAISDELL. Yes; it would not be over 88 or 90. We have no trouble in getting all the labor we need.

The CHAIRMAN. The people who work here are healthy?

Mr. BLAISDELL. Yes. The only thing we have to be careful about is not to drink an unlimited quantity of ice-water when working out in the sun. I will state that we have no difficulty in raising all kinds of oranges.

STATEMENT OF O. T. S. INGALLS, OF YUMA.

The CHAIRMAN. What is your occupation?

Mr. INGALLS. I am a farmer at the present time.

The CHAIRMAN. State where you are farming and what are the results you obtain.

Mr. INGALLS. I will state that I am occupying a piece of land in town which I am leveling and getting ready to cultivate when I get sufficient water. I propose to use pumps so soon as my land is in a condition to work. At the present time I have not done anything.

The CHAIRMAN. Do you know what kind of farming is principally carried on here—what do you raise?

Mr. INGALLS. Mostly fruits—oranges, lemons, limes, dates, pomegranates, figs, apricots, pears, and peaches.

The CHAIRMAN. Is the land well adapted to the raising of such fruits?

Mr. INGALLS. We find no difficulty in raising them, and we get them very early in the season. They grow very rapidly, and we get various varieties.

The CHAIRMAN. How are they as to quality?

Mr. INGALLS. Very fine as to quality, and the yield is good. We have also made some experiments with sugar-beets. We find that we can raise them here by planting them two seasons of the year, one crop in March and the other in October. In that way we have them growing the whole year round. We sent a sample of our sugar-beet to San Francisco, and it was reported to contain 17 per cent. of sugar. That is a very fine return. Then we have wild hemp. This grows on the overflowed lands of the Colorado. It grows without any irrigation immediately after the overflow, and this sample [producing] was obtained by putting the sticks of the hemp in water and allowing it to wash off the gum.

The CHAIRMAN. What height does it grow?

Mr. INGALLS. From 12 to 14 feet in height.

The CHAIRMAN. How is it as to quality?

Mr. INGALLS. It is considered to be a very fine quality. We have been offered 8 cents a pound for that material.

The CHAIRMAN. That grows down in the Mexican territory, also.

Mr. INGALLS. Large quantities grow in Mexican territory.

Senator REAGAN. Is there any one engaged in putting it into this condition?

Mr. INGALLS. No; that was done for experimental purposes. I saw a party in San Francisco who had just returned from Paris, and he stated they were anxious to get it.

The CHAIRMAN. Is the territory here large?

Mr. INGALLS. Yes; hundreds of thousands of acres. Cotton grows here year after year.

Senator REAGAN. From the same stump?

Mr. INGALLS. Yes, and Judge Brinley has had some trees growing in his yard for some years.

The CHAIRMAN. Is cotton cultivated here so as to enable you to speak of the quantity produced?

Mr. INGALLS. It is not.

Senator REAGAN. You do not know how much is produced to the acre?

Mr. INGALLS. No.

STATEMENT OF CHARLES H. BRINLEY, OF YUMA.

The CHAIRMAN. How long have you resided in Yuma?

Mr. BRINLEY. Twenty-odd years.

The CHAIRMAN. Have you observed the production of crops here by irrigation?

Mr. BRINLEY. Somewhat.

The CHAIRMAN. And you have engaged in it to some extent?

Mr. BRINLEY. As a gardener.

The CHAIRMAN. What is the character of crops produced here?

Mr. BRINLEY. In former times there was produced wheat, barley, and hay. They were the principal crops. That was a number of years ago. That was when the government was here.

The CHAIRMAN. Then you had a market for that class of crops?

Mr. BRINLEY. Yes. Since that time it has been nondescript in its character. With Mexicans and others it never rose to the dignity of a crop. So soon as the railroad was established, and when we were able to get water from our pipes, etc., we commenced our gardens. So far as that is concerned, I can speak from a personal stand-point. I have put in oranges, lemons, limes, figs, olives, pomegranates, plums, a variety of flowers, cotton and one or two trees from Sonora, a kind of wild tamarind. I have planted the tamarind and found it to grow well and free. You could produce ornamental trees and bananas.

The CHAIRMAN. What success have you had in them?

Mr. BRINLEY. Good success.

The CHAIRMAN. You have raised each of those?

Mr. BRINLEY. Yes. I have raised bananas. I am speaking from a crop stand-point. I do not think bananas would answer?

The CHAIRMAN. What would then.

Mr. BRINLEY. Oranges, limes, and lemons.

The CHAIRMAN. What success have you had in oranges?

Mr. BRINLEY. Admirable. I could demonstrate that better if you were to step off the cars and see my oranges. I have but two trees. I have them in my garden, the Marianna Sweet, and it is as clear and delicious a fruit as you ever saw, without a speck, beautiful in color, and just a few seed.

The CHAIRMAN. Do they produce largely in quantity?

Mr. BRINLEY. Abundantly.

The CHAIRMAN. As much as the trees will bear?

Mr. BRINLEY. Yes; and when they are in flower I never saw anything like it. I have seen an abundance produced on oranges and lemons; but in this place there appears to be a struggle as to which tree can produce the most.

The CHAIRMAN. How much of this country is suitable for oranges of that kind?

Mr. BRINLEY. That has to be experimented upon. I can not answer as to that, because my operations are limited.

The CHAIRMAN. To Yuma?

Mr. BRINLEY. To a small area near it; but I judge, with proper care, we could hardly name the limit in this county.

The CHAIRMAN. Where were the dates raised that we see here?

Mr. BRINLEY. They were raised on the Colorado, about 6 miles from here.

The CHAIRMAN. Am I to understand that there is an abundance of water in the Gila River in the spring?

Mr. BRINLEY. Yes; in the winter-time.

The CHAIRMAN. Covering a large extent of country?

Mr. BRINLEY. Yes.

The CHAIRMAN. How is this country with regard to its healthfulness?

Mr. BRINLEY. Perfect. I am rather a good specimen for the number of years that I have lived here. I have been sick but once, and I have not slept in my house for thirteen years. I sleep out of doors. In the winter-time I sleep under a corridor.

The CHAIRMAN. What effect would this climate have upon consumptives?

Mr. BRINLEY. If they come here at not too late a period in the disease, I think they can be improved in every instance. I do not think, however, any one could stand the extreme hot weather. But if they came here in the winter and gradually worked into it, I think they could stand the heat and be wonderfully benefited by the country.

The CHAIRMAN. How would it do to spend the winter here and the summer at Santa Fé?

Mr. BRINLEY. That might do. So far as this climate is concerned, in the winter-time it is admirable.

The CHAIRMAN. Do persons contract consumption here?

Mr. BRINLEY. I have never known a local disease; everything that has occurred here was some person who was brought here sick. We have had sporadic cases of measles and small-pox. But that is milder in form than it is anywhere else; the fatality is insignificant as compared with other places.

STATEMENT OF J. H. TAGGART, OF YUMA.

The CHAIRMAN. State what your experience has been in fruit-raising in this country.

Mr. TAGGART. Outside of a garden I have had no personal experience. About six years ago, when we got our water, we put in some trees, some oranges, lemons, limes, figs, grapes, a variety of flowers, tube roses, and the whole list. My wife attended to that department. The success in everything has been all that could be expected, and even more, in some instances. The citrous fruits we have found to improve in quality from what they were when transplanted from California. The skin becomes thinner, the flower finer, and the seeds fewer. The quality of citrous fruit is equal to the Sonora limes, lemons, etc.

The CHAIRMAN. Do you think you can raise as good oranges as they can at Sonora?

Mr. TAGGART. I have never tasted a better orange than I have gotten here. I have compared them with the Sonora oranges, and found them fully their equal. They are much better than the Riverside oranges, or the best Florida oranges.

The CHAIRMAN. How much country have you in which you could raise oranges like the Sonora oranges?

Mr. TAGGART. It is estimated that we have in this country some half million acres, and I do not know any reason why the fruit should not be raised over the whole area.

The CHAIRMAN. It is very similar to the land on which you raise oranges.

Mr. TAGGART. Yes, except that throughout the county the soil is excellent, and here in Yuma we are in a sand-hill. So that, we are at a disadvantage here, where we have gardens. A few months ago we put out some blue figs, and to-day they represent trees 10 and 11 inches in diameter. Before the slips are a year old we gather fruit from them, and from some of them we have gathered two or three times a year. We get bushels from each tree every season. The yield is simply immense. Some varieties of grapes do not color here as well as they do elsewhere; but they are of a finer flavor than I have seen elsewhere.

The CHAIRMAN. Would this be a good place to cultivate raisin grapes?

Mr. TAGGART. Yes. I have had bunches of raisin grapes on the ground in the garden exposed to the sun, and in eight or nine days pick up as fine raisins as I would want to use, and without giving further attention. They do not become sun burned under such circumstances, and the atmosphere is so dry that we have no difficulty at all. There is no necessity to protect the crop.

The CHAIRMAN. You can dry them almost any season of the year?

Mr. TAGGART. Yes. We claim from four to six weeks earlier than California in ripening most fruits, especially grapes. We can discount that time. I took from my garden this season in May ripe grapes of the standard varieties—Black Hamburgs, raisin grapes, Black Malaga, Muscatelles, etc. So that we could have gathered freely had we vineyards from the 10th to the 15th of June.

The CHAIRMAN. You would have the eastern market two months earlier than your California neighbors.

Mr. TAGGART. That is what we claim; and we could hold it.

The CHAIRMAN. Are your citrous fruits ripened much earlier than theirs?

Mr. TAGGART. Our limes are. Here are are some limes just picked from the tree [producing].

The CHAIRMAN. What is the general character of the soil through this country?

Mr. TAGGART. It is deep, from 10 to 20 feet on the valley; on the mesas it is different—more iron, and somewhat more gravelly, and of unknown depth.

The CHAIRMAN. Are the mesa lands fertile when you get water onto them?

Mr. TAGGART. Yes, they have produced abundantly wherever we have had water on them, seemingly as well as in the valley.

Director POWELL. How long have you lived here?

Mr. TAGGART. Twelve years.

Director POWELL. Have you kept a rain-gauge in this section

Mr. TAGGART. No.

Director POWELL. Do you know any one who has?

Mr. TAGGART. The Signal Service.

Director POWELL. Do you know what the rain-fall has been here in late years?

Mr. TAGGART. They have registered between 2 and 3 inches—2 inches and a fraction.

Director POWELL. Have you ever been west 50 or 60 miles?

Mr. TAGGART. Yes.

Director POWELL. So as to know a good deal about that country?

Mr. TAGGART. Fairly well.

Director POWELL. Does the rain increase going westward?

Mr. TAGGART. Yes.

Director POWELL. How much is the rain-fall within 100 miles of here, not along the coast, but out on the desert?

Mr. TAGGART. The rains out on the desert are very frequent and very heavy. They have washouts there, and we seldom have rain here. That is the best comparison I can give. But it is certain the rain is very much greater as you go west, and I think you will find a material difference in a hundred miles.

STATEMENT OF LOUIS A. HICKS, OF YUMA.

The CHAIRMAN. What is your occupation?

Mr. HICKS. Civil engineer.

The CHAIRMAN. Have you made surveys in the vicinity of Yuma?

Mr. HICKS. Yes, I have been located here some time. I have been engaged in the construction of irrigation works for the last year and a half.

The CHAIRMAN. Have you any maps representing your works or any portion of them?

Mr. HICKS. The intention is to send you blue prints so soon as we can have them prepared.

The CHAIRMAN. You will forward them to Washington?

Mr. HICKS. Yes.

The CHAIRMAN. Can you state the amount of irrigable land in this county?

Mr. HICKS. The amount to be irrigated approximates 600,000 acres, and of that we estimate that 450,000 acres will be good land. The other 25 per cent. is land of not entirely good character; it is irregular or sandy, or for some other reason broken up, so that it is not available for cultivation.

The CHAIRMAN. How would you irrigate the land?

Mr. HICKS. By means of a storage dam, the dam to be 100 feet high.

The CHAIRMAN. Have you ample water to supply it?

Mr. HICKS. Yes. The Gila River in the winter would fill any reservoir that could be built. I have seen flood places 3½ miles wide.

STATEMENT OF E. G. TRIPPEL, OF YUMA.

The CHAIRMAN. How long have you resided in Yuma?

Mr. TRIPPEL. I have been here about two and a half years.

The CHAIRMAN. Have you a report prepared by the citizens or by some organization with regard to irrigation in this county?

Mr. TRIPPEL. Yes.

The CHAIRMAN. State by whom it was prepared, and why?

Mr. TRIPPEL. It was prepared for your use by a committee appointed by the citizens at a mass-meeting held for that express purpose. I, under the direction of this committee and with its assistance and au-

thority, have prepared this data. It is a report which we presume will be of some use to the committee.

The report is as follows:

REPORT OF THE CITIZENS' EXECUTIVE COMMITTEE OF YUMA COUNTY, ARIZ., TO THE SENATORIAL COMMITTEE ON THE IRRIGATION AND RECLAMATION OF ARID LANDS.

[Written and compiled by E. J. Trippel, secretary of the committee, under the direction and by the authority of the Citizens' Executive Committee, September 3, 1889.]

Members of the executive committee: C. H. Brinley, F. S. Ingalls, F. L. Ewing, S. Purdy, C. E. Spencer, A. Frank, Hiram W. Blaisdell. Officers: H. W. Blaisdell, chairman; E. J. Trippel, secretary.

This report has been prepared with the view of presenting to the Senatorial Committee on the Reclamation and Irrigation of Arid Lands data pertaining to the climate, rivers, lands, irrigation facilities, available water, storage sites, peculiar products, water supply, and such other points as are properly connected with a truthful statement of the present condition and future possibilities of the agricultural interests of Yuma County, Ariz.

Immediately following the correspondence between Col. R. J. Hinton, irrigation engineer of the U. S. Geological Survey, and the governor of Arizona, relative to the proposed visit of the Senatorial committee to various portions of the Territory, the governor issued a proclamation requesting the different county supervisors to take prompt action in the matter of collecting suitable data for the use of the visiting committee. In compliance with the call an enthusiastic meeting was held in the town of Yuma by the citizens on the 8th of July, 1889, and plans of action formulated to this end. An executive committee of seven were appointed and authorized to take in hand the collection and computation of the requisite data and also the direction of such additional details as might to them seem necessary.

This committee, therefore, in behalf of the citizens of Yuma County, respectfully submit for the consideration of the Senatorial committee the following report, accompanied by maps from the surveys of Messrs. L. A. Hicks and J. B. Steiger, both eminent civil engineers, showing the area of fertile and irrigable land in and about the lower portions of the Gila and Colorado Valleys, and also the proposed site of an immense and perfectly practicable water-storage reservoir with a capacity more than sufficient to furnish the means of cultivation to hundreds of thousands of acres of arable land, much of which is now lying idle, useless, and unproductive. No attempts have been made to exhaustively review the subject in all its ramifications, and yet enough might be written upon our numerous and varied resources to fill a volume. It has rather been the purpose to briefly touch upon the more important points, including the many peculiar and almost unique features showered upon this really favored though apparently cruelly neglected, region. Unfortunately, however, there are among the most valuable of our natural gifts a number quite latent and dormant, and so they will remain until the Government in its wisdom sees fit to quicken them into life, and by affording the necessary facilities for storing water against the seasons when it is most needed, bring about a wondrous and magical change in contradistinction to the present state of affairs.

These pages are sent upon their mission with the hope of attracting the attention of the statesmen high in the councils of the nation to the

plainly manifested necessities of Yuma County. It is believed that when it is once accomplished the desired results will follow as a matter of course, and thousands of happy, prosperous, and contented citizens will live to bless the practical efforts of a wise and benignant Government in effecting so thorough, so radical, and so desirable a change.

CITIZENS' EXECUTIVE COMMITTEE.

PHYSICAL AND TOPOGRAPHICAL FEATURES OF YUMA COUNTY, ARIZ.

Yuma County, one of the four original political subdivisions of the Territory when first established by act of Congress, on February 24, 1863, as an independent Commonwealth, forms the extreme southwestern portion of Arizona. It lies between 32° and 34° 24′ north latitude and 113° 20′ and 114° 14′ west longitude. It is bounded by Pima, Maricopa, and Yavapai Counties on the east, the Colorado River on the west, Mohave County on the north, and Sonora, Mexico, on the south. It has an area of 10,138 square miles (6,448,320 acres), an expanse greater than either of the seven smaller States of the Union, and larger than Connecticut, Rhode Island, and Delaware combined.

For more than 100 miles it is crossed from east to west by the Gila River, which thoroughly drains the southern and western portions, eventually emptying into the Colorado at the town of Yuma, while the Colorado washes its western boundary, effectually draining the remainder.

The topographical configuration of the surface includes a series of wide plateaus rising gradually from a point situated at the southwestern extremity with an altitude of about 60 or 70 feet above sea-level, to an elevation in the north and northeast very much greater, the whole sloping gently in a southwesterly direction. These plateaus are crossed by numerous mountain ranges, especially in the northern part, the ranges being separated by broad valleys, many consisting of excellent lands. The various mountain systems, though rough and abrupt in character, are highly mineralized, carrying gold, silver, copper, lead, iron, and other minerals in paying quantities. The eastern and southern portions include gradually-sloping plains covered in places with native grasses and trees, among the latter being the mesquite, ironwood and paloverde. Here and there are detached hills and mountain spurs, often of eruptive origin.

All that country embraced within the county confines, situated north of the natural water-shed of the Gila River, owing to the slight rain-fall and few streams from which water can be taken for agricultural purposes, is practically worthless, so far, at least, as the feasibility of bringing large bodies of irrigable land under cultivation is concerned. The available arable region, therefore, is limited by nature to broad strips of country lying directly north of the Gila and east of the Colorado Rivers, and also hundreds of square miles of splendid land stretching directly southward from the Gila River to the Sonora (Mexico) frontier. Consequently it is upon these rivers that water-storage reservoirs must be established.

It is more than probable that less is known of the physical and topographical peculiarities of Yuma County than of any other county in the Territory. According to the map of the Interior Department, issued from the General Land Office in 1883, it is shown that less than 10 per cent of the total area was surveyed by the Federal authorities. It is believed that no further surveys have been ordered since the date mentioned, and therefore, so far as official recognition extends, more than nine-tenths of the country is a veritable *terra incognito*. The population numbers 2,500 souls and the valuation of taxable property reaches in round numbers $800,000.

RIVERS.—The Gila River, though second in size to its mighty rival, the Colorado, is destined for the present, at least, to figure far more prominently in the solution of the problem of redeeming and making valuable to the husbandman the immense bodies of hitherto arid and worthless lands tributary to it.

The Gila drains a vast territory. Rising in the western part of New Mexico, it flows in a nearly westerly direction through the entire Territory of Arizona. Its northern and eastern sources are among mountains covered for several months in the year with snows of varying depths, the melting of which, added to the many natural springs emptying into it at different points, form a considerable river long before it passes through Graham County. It enters the latter county in the neighborhood of the Clifton Copper mines, then courses through the Pueblo Vieja Valley and the San Carlos or White Mountain Indian Reservation, finally entering the Gila Valley some 5 miles above Florence, thence for nearly 300 miles it winds through the now famous Gila Valley, eventually merging into the large stream at Yuma.

The entire course of the river is erratic and irregular, as it follows a naturally tortuous route caused by the diversified character of the country traversed. The total length from its source in New Mexico to its confluence with the Colorado, including

its many windings, is fully 650 miles. Before reaching the eastern boundary of Yuma County it is fed by numerous rivers, among the most important being the San Pedro, a singular stream, rising near the line between Sonora and Arizona and draining the Huachuca, Mule, Caliuro, Dragoon, and Whetstone Mountains, and also the eastern slope of the Santa Catalinas. Flowing northerly for more than 100 miles it enters the Gila River at the southern extremity of Gila Cañon, in Pinal County. Along its course the rain-fall is perhaps greater than elsewhere in Arizona, being estimated at 24 inches yearly in the vicinity of the Dragoon Mountains. Certain of the ranges mentioned are during winter frequently covered with snow, which on some do not disappear until the commencement of summer.

Another notable tributary is the Salt River, in itself a large stream, having its headwaters in the White Mountains, near Green's Peak. It rises in the eastern portion of the Territory, draining the mountainous region in the far north, including among others the San Francisco, Sierra Ancha, White, Apache, and Tonto Basin Mountains. Among the most important streams that feed it may be mentioned the Verde River and Tonto, Raccoon, Cherry, Cañon, Cibica, Carrizo, Cedar, Pinal, and Perito Creeks. Its general direction is west and south, until it empties into the Gila some distance below Phœnix, its entire length closely approximating 200 miles. An important adjunct towards increasing its volume is the heavy rain-fall about Prescott, amounting during the past ten years, as is shown by the reported observations of the United States Signal Service office at that place, to an average of 15.18 inches annually. Much of its waters are used in irrigating its own valley at Phœnix, but the waste water of the Salt River Valley, irrigating canals is gradually returned in part through seepage to the Gila, thereby augmenting the latter. Other rivers, like the Agua Fria, Hassayampa, etc., bring down further supplies drained from the heavily-timbered mountain region traversed by them, pouring their precious stores into the Gila.

Thus for the major portion of each year the Gila carries a large stream, more than sufficient, in fact, to irrigate its own valley, a domain princely in extent. During the summer months, however, owing to the extremely dry and heated climate, extraordinary rapid evaporation, decreased supply at its headwaters due to the cessation of springs and snows, and, also, the peculiarity, during the heated term, of drying in its bed for many miles, rising and sinking at intervals as the bed-rock approaches or recedes from the surface, the available supply falls short of the demand, leaving hundreds of thousands of acres in the lurch, and that, too, at the very time when ample irrigation facilities are the most needed. For this reason alone if for no other dams and other constructions for storing water against such times are imperatively needed and should be inaugurated as early as possible. None of the streams so far touched upon are navigable.

The Colorado.—The Colorado River is formed by the union of the Green and Grand Rivers. The former rises in Wyoming, near Fremont's Peak, and, running southerly, joins the latter in Utah. The Grand River rises near Long's Peak, in Colorado, and, running in a southwesterly direction, meets the Green as stated. From their juncture the stream takes the name of the Colorado, and, following a general southerly course, empties into the Gulf of California. The entire length, including tributaries, is over 1,200 miles. It flows during the low-water period at a rate not exceeding 4 miles per hour, although, of course, the speed is very much greater when the river is high. Among its principal tributaries are the Rio San Juan, the Colorado, Chiquito, the Bill Williams River, and finally, as already explained, the Gila. The Colorado constitutes the entire western boundary of Yuma County, it stotal length between the Sonora line and the mouth of Bill Williams River, being about 235 miles, the latter forming its northern boundary, separating, as it does the counties of Yuma and Mojave. It is navigable during high water for nearly 650 miles, from the Gulf of California to the Virgin River, by steamers registered and licensed through the customs district of Paso del Norte.

The river is capable of affording at all periods an almost incredible amount of water for irrigation purposes, sufficient, in fact, to bring hundreds of square miles of fertile lands on each side of the river under cultivation besides supporting an enormous population. Near Yuma the current sometimes attains a speed of 4 knots per hour, with an average depth of 10 or 12 feet.

The Bill Williams fork unites with the Colorado at Aubrey. Rising in the mountains southwest of Prescott it flows southerly and westerly to its mouth a distance close upon 150 miles. Its chief tributaries are the Santa Maria and Big Sandy Rivers. It passes through a region much distorted and disturbed by past volcanic influences and containing but little tillable land. Consequently, so far as the intents and purposes of this report are concerned, the Bill Williams River, being devoid of extensive agricultural and irrigation facilities, will not be further treated.

ARABLE LANDS.—Within the county limits there are large aggregations of Government land. The majority of the most favorably situated in the valleys were the first taken, the early pioneers occupying the tracts nearest the rivers for the reason that

they could be more cheaply irrigated. The mesas are entirely unoccupied, although they comprise much of the most desirable land, such especially as are adapted to the growth of the citrus and other semi-tropical fruit. Water can not easily be brought upon them on account of their elevation above the river bed. Canals capable of carrying sufficient water for irrigation would entail comparatively heavy expense, because many miles must necessarily be constructed before the water can be brought to the surface. Such outlay would prove far too excessive for the slender resources of the average settler, and so, as matters stand, they lie scorching under the burning rays of a semi-tropical sun untouched by the spade and plow.

This condition of things, however, can not long continue. Neither physical nor topographical difficulties exist that can not be surmounted by the expenditure of a reasonable amount of capital, and consequently it is only a matter of time when the completion of constructions of this nature will be effected by private corporations or by the Government. There are but few points along the slopes of the many mountain ranges calculated for farming locations. Such places are generally situated where small living springs afford the means of irrigation for a few scattered acres. Above the Gila are great sloping plateaus which may in the future be placed under cultivation provided the boring of artesian wells is prosecuted extensively. As the surface inclination is toward the river, commencing many miles away from its nearest point, the bringing of water from the Gila itself is entirely impracticable and other methods must be adopted. It may safely be assumed, in view of what has just been explained, that the large bodies of available agricultural lands are confined to the valleys of the Gila and Colorado, and also to the comparatively level plains stretching from the Gila River to the Mexican line.

The Gila Valley is by far the most important of the two from an agricultural stand-point. It extends from the Gila Cañon, near the junction of the San Pedro River, westerly to the east banks of the Colorado, a distance slightly exceeding 250 miles. That portion of it situated in the county of Yuma, and known as the Lower Gila Valley, is about 100 miles long by from 2 to 16 miles wide, all of which is susceptible of profitable cultivation. The river from which it takes its name cuts the valley in two. Its water-shed extends some 30 miles north and upwards of 50 miles south of its channel, the land from either extreme inclining more or less rapidly towards the stream. The Gila traverses a marvelously fertile country, very great in extent, and splendidly adapted to the cultivation of nearly all the products of the temperate and semi-tropic zones, besides many of the fruits common in the tropics. Nor is this longer a matter of idle speculation, for flourishing ranches in various portions of the valley and drawing water from several important canals amply demonstrate the magnificent results that will ensue should the water supply be rendered permanently equable and adequate through appropriate storage systems. The following, taken from "The Hand-Book to Arizona," by Col. R. J. Hinton, alluding to the valley in question, is as interesting as it is accurate.

"This consists of a broad expanse of tillable valley land, sometimes overflowed by the river, which is at times 'mighty uncertain' and a steep range of volcanic hills coming close to the highways is for a dozen miles or so hot, heavy, and sandy. It is hardly fair to say sandy, as it is really a friable alluvial loam of grayish hue and loose texture. Several ranches are passed, showing that the Gila bottom is cultivable. With irrigation every square mile of the Gila valley is capable of producing prolific crops of grains and semi-tropical fruits, as well as cotton and sugar in great abundance. The river is able to furnish all the water needed, and a good deal more. It would take no very great skill in engineering, and not a very large sum of money either, to construct reservoirs or lakes in which to receive and store the overflow. There are natural basins or dry lakes into which by simple means the water could be conveyed."

The lands situated in and about the Gila valley may conveniently be classified as follows:

(1) The bottoms or overflowed lands.
(2) Slightly higher valley lands not subject to overflow.
(3) Mesas or sloping uplands.
(4) High but comparatively level plains.
(5) Mountains.

The bottoms and higher lands.—The bottom lands, as well as those slightly higher, stretch along either side of the Gila River for varying distances north and south until they meet the more elevated mesas which rise abruptly from the valley. The bottoms lie immediately along the river and are subject to inundation annually. Immediately following the subsidence of the waters the local Indians were in former times, accustomed to plant corn, pumpkins, melons, and other vegetables. These sprung into maturity with startling rapidity, rarely failing to yield bountifully without additional irrigation. The custom is occasionally followed by resident farmers to this day with excellent results, although but a single crop can be harvested. These bottoms form, perhaps, 25 per cent. of the valley lands, and may without par-

ticular difficulty be secured from further invasion by a system of dikes and levees if deemed necessary or desirable. The soil throughout the valley is a rich brownish yellow sandy loam, generous, mellow, and porous, with a depth ranging from 6 to 20 feet, the whole resting upon underlying stratas of gravel and sand that readily carry from the surface such excess of water as might otherwise prove injurious to seeds and growing plants.

There is unmistakably geologic evidence that the entire lower Gila valley was, during some pre-historic period, covered with water, constituting, in fact, an enormous lake, the surface rising in places to the upper portion of the outskirting mesas. The soil lying at the bottom was made by the washing and erosion of the surrounding mountains. The soda from the decomposed vegetation, the magnesia and lime from the magnesium lime formations, and the potash from the decomposing granitic rocks were carried with unceasing regularity year by year until deposited in the bottom. Eventually, upon the disappearance of the lake, the rich, fertile alluvium, than which there is none better, was left to reward the efforts of the modern husbandman. But nature, not yet satisfied with her handiwork, directed the accumulation of the detritus washed from the distant mountainous region. As a result the soil is extremely rich in the elements best adapted to thorough fertilization, for it contains a certain amount of organic matter, which, on decomposing, further enhances its agricultural value.

By constant overflow and change of channel the deposits are equally distributed over considerable areas, the process continuing through centuries. These soils are further enriched by decomposed inorganic contributions, including the sandstones, limestones, marls, shales, etc. Besides the ingredients mentioned a chemical analysis shows that iron, ammonia, and phosphoric acid enter into its composition in the proportions best adapted to add to its fertilizing qualities. The extremes of temperature are somewhat greater than on the high lands, but there is also more moisture.

The bottom lands are so easy of cultivation that it is not uncommon, after clearing the surface from brush and stubble, to pass over the ground with an ordinary cultivator a single time, afterwards sowing to grain or grass. In three or four months large crops are harvested, the soil meanwhile being entirely innocent of the plow. All plants seem to grow rapidly, maturing remarkably early. Indications of ancient ditches are apparent throughout the valley, showing plainly the existence of irrigation works by the ancient Aztecs. Curiously enough, in certain instances the identical routes of these long-extinct people have been followed for considerable distances by their modern successors.

The MESAS.—The mesas are warmer and better adapted to the cultivation of citrus fruits. The soil is also somewhat different, being of a reddish color, and loose enough to receive water without causing the ground to bake. While of a loamy nature, it is more sandy or gravelly. It is also lighter, but therefore better adapted for the culture of the fig, the olive, and the various kinds of wine grapes. Indeed, it has been asserted by several of the most experienced wine growers of California that these very mesas are better calculated for the production of the true port and sherry grapes than any of the lands within the borders of their own grand State. It is claimed that wine can be made possessing preserving qualities such as would allow of improvement year by year, instead of deterioration. These lands are greater in area than those directly upon the river, and almost imperceptibly slope away from the distant mountains. The drainage is admirable, not too excessive, and just sufficient to carry off surplus water. Vegetables, grasses, grains, sugar beets and cane, cotton, and, in truth, almost everything can be raised successfully.

The HIGH *plains.*—These include extensive bodies of land connecting with the mesas along the south side of the Gila valley. So gradual is the slope that they hardly deviate from the horizontal. At the highest point southwards they as gently incline towards the Mexican line, the slope in this case being directly opposite to that along its northern base. In the latter instance it is first towards the mesas, and from thence indirectly to the river. The soil is very similar to that of the mesas, the two classes exhibiting common characteristics. Like the mesas, these plains are susceptible of the highest cultivation, providing always that sufficient irrigation facilities are afforded. Here and there they are crossed arbitrarily by mountain ranges, which do not all trend in the same direction, but they present no important engineering obstacles to the canal builder.

The wonderful fertility of the bottoms and other valley lands, as well as the mesas and high plains, is established beyond denial by actual experimentations. Neither is the soil likely to degenerate in the future, for in answer to the question, "Will it last," O. L. Wheeler, D. D., LL.D., a recognized expert in such matters upon the Pacific coast, says:

"To this query the answer in general is the longer land is properly cultivated and properly fertilized the stronger and more productive it becomes. While the mountains surrounding the valley continue to disintegrate under the operation of the elements, and while the detritus thus eliminated continues under the laws of gravitation

to descend and work its way over the plains, so long will there be perennial additions to the amount of producing element in a state of refinement and assimilation. And so long as the water flowing from these mountains, holding in solution the débris which always in some degree is spread upon the land in irrigation, so long will the fertilizing properties of the soil continue to receive additions and its fecundic power will continue to be increased. And so long as the water, containing more or less of salts and ammoniac compounds, as all water does, is used for irrigating purposes, and so long as the process of cultivation continues to throw up the soil, exposing it to the indispensable and even fructifying influences of the atmosphere, so long will the soil continue to be refreshed and invigorated and prepared to give larger rewards to the labor of the husbandman."

MOUNTAINS.—The mountains forming the last and outer environments are, of course, in no way to be discussed. Nevertheless they play an important part in the advancement of the agricultural interests of the valley by shielding, more or less, the lower lands from the effects of the high strong winds that prevail at times.

The total acreage of the Gila Valley and outskirting lands, as just described, is estimated at 600,000 acres, of which there are 33,000 acres of bottom lands, 97,000 acres of higher valley lands, and 470,000 acres of mesas and level plains. By far the largest portion of the valley has been filed upon, under one or other of the Congressional enactments. The entire amount under actual cultivation will probably not exceed 1,500 acres at the present time although, owing to the recent completion of one of the most prominent irrigating canals, it is believed that between 3,000 and 5,000 acres additional will be worked during the coming autumn and winter. The writer is credibly informed that 5,000 acres or more have either been patented or are nearly ready for final proof.

THE VALLEY OF THE COLORADO.—Several miles above Fort Yuma, in the neighborhood of Explorer's Pass, near the Purple Hills, the great Colorado Valley proper commences. From this point northerly the river is shut in by cliffs which, with intervening mountain systems, absolutely precludes the possibility of canal construction. Passing southwards the cliffs are seen to gradually disappear until they become merged in the low bottom lands. The valley meanwhile widens with every mile until the Gulf of California, in Mexican territory, is reached. There are large quantities of land which could be made productive were irrigation practicable. These are generally fertile bottoms, inclining towards the river, and covered in spots with dense undergrowth and cotton-wood and mesquite trees. Considerable of the valley is raised above the river as much as 100 feet, and to this height water must be brought as the bottoms are, during certain months of the year, entirely overflowed by the waters of the swollen stream. The soil is extraordinarily rich and particularly adapted to the cultivation of sugar, rice, and all the textile plants, in addition to an extended list of tropical, semi-tropical, and temperate products. According to careful chemical analysis the fertilizing reddish mud carried by the Colorado closely resembles the waters of the Nile, while its volume at low water has been estimated by competent authority as sufficient to easily irrigate more than 1,750,000 acres.

Until recently the construction of adequate canal systems was considered impracticable. That such is not the fact is shown by the following, reprinted from the pamphlet on "The Resources of Yuma County," published in 1887, by Hon. Cameron H. King, late Commissioner of Immigration for Arizona.

THE GREAT COLORADO CANAL.—One of the most important irrigating enterprises which will, above all others, be productive of the greatest benefit to Yuma County is the proposed canal from the Colorado River.

George W. Norton, a civil engineer of acknowledged great ability and distinguished reputation, has made careful surveys and estimates for this gigantic undertaking, which, if completed as designed, will bring more than 1,000,000 acres under irrigation and cultivation.

The Colorado and Gila Rivers have their confluence at Yuma. The course of the Colorado River, looking up stream from this point, is northeasterly for some 25 miles, and then turns to the north, while that of the Gila is almost due east. Some 18 miles above Yuma commences a range of hilly country, flattening out at its sides into table-lands, and this range separates the two valleys until they finally diverge at right angles. Between this point and Yuma both valleys join and merge into one cut, from east to west, by the channel of the Gila River.

The Colorado Canal will head at a point about 28 miles above the town of Yuma, and will be carried around the hilly country above alluded to, across the Gila River, through pipes or flumes. It will irrigate the land lying between the Colorado and Gila Rivers, and also the land embraced by the table-lands on the south and the Gila River on the north, making fully 25,000 acres above Yuma, subject to redemption. Below Yuma, all the land between the line of table-lands and the Colorado River, as far as the Mexican boundary line, will be reclaimed, some 70,000 acres, and when carried onto the table-lands will redeem 80,000 acres more—a grand total, in Arizona, *of 175,000* acres of as fine land as there is on the continent.

If this canal can be carried on into Sonora, by concession from the Mexican Government, it will make productive what is estimated at 1,000,000 acres of land. The cost of this canal system, from its source to the boundary line, will roughly approximate $2,000,000. The width of the canal will be 50 feet on the bottom.

The Colorado Canal heads opposite Stevenson's Island, a rocky protuberance which rears its head above the surface of the water in mid-channel of the Colorado River. This is the only point on this river, for a great many miles, from which an irrigating canal can be taken, owing to the fact that there is such a slight fall to the river it necessitates many miles of expensive work before the water can be brought to the surface of the land. Stevenson's Island, above alluded to, acts as a dam to the waters, raising their surface several feet from the level of which the river rushes with tremendous force and rapidity. In a distance of less than 600 feet there is a fall of fully 4 feet. From this point the taking out of the proposed canal is not only practicable but comparatively a simple and an inexpensive matter. At Stevenson's Island it is proposed to erect a dam and lock, which will not in any way impede or interfere with the navigation of the river, but will be of sufficient capacity to allow the largest steam-boats and barges to pass through. This lock will be so constructed as to raise the water 12 feet above low-water mark. One of the objects in thus raising the water is to enable the canal to cover much more of the table or mesa lands than it otherwise would, but the principal advantage to be gained is that since the water of the Colorado at times holds a very considerable amount of mud or sediment, sometimes as much as 10 per cent., the raising of the water by means of the dam or lock will cause the greater portion of this sediment to be precipitated and the water will thus be partially settled and cleared.

By means of waste-gates and the lock this precipitation of mud is easily cleared out, so that it can not encumber or fill up the canal. The bottom of the canal will be above the bottom of the lock. Waste-gates and sluice ways along the canals, at intervals for a distance of 3 miles, will clear out any surplus of mud in the water, so that the canal will not carry any more sediment than enough to act as a fertilizer.

A bill carefully prepared is to be presented to Congress to obtain permission to construct the proposed lock, and as there can be no objection to it, since it will assist rather than impede navigation by overcoming the heavy fall at this point in the river, there is little doubt that the measure will meet with legislative sanction. The advantages of this great Colorado canal not only lies in the increased quantity of land made subject to redemption, but it will form a most important factor in furnishing this necessary water supply, owing to a peculiar providence of nature. The high-water periods of the Colorado and Gila Rivers alternate, the former having its greatest rise in summer, at which period water is most needed and useful.

Nor does the grand project benefit Arizona alone, for from the western bank of the Colorado at the lock at Stevenson's Island, a large canal will also be taken out of the California side, which will irrigate an immense tract of land in the Golden State and aid in advancing the prosperity of the town of Yuma, which will thus become the center of one of the largest agricultural districts in the West. It is almost impossible within the space allowed for this description to illustrate all the wealth which must necessarily accrue from the construction of such a system of irrigation, or to call attention to all the points of feasibility in such construction. The whole matter is open to investigation.

IRRIGATION.—The question of irrigation has nothing new about it. While the history of remote times exemplifies the endeavors of the people to enlarge and improve upon their methods, the same history depictures abundance and happiness upon the one hand and scarcity with entailed distress upon the other. The methods of to-day among our own people have not yet reached the most economic point. Correct judgment in the use of water, resulting from the experience gathered from an extended and diversified field, will be the future guide.

In this vicinity, a capricious supply of water, under an irrigating system, will return nothing but defeat. Water must be permanent and abundant. The land must be saturated at regular intervals as may be found necessary. The average annual rain-fall, as shown by the Signal Service reports, calculated for the past ten years, is but 2.7 inches, and this, every one will admit, does not, and can not, in itself suffice for the needs of the irrigationist. It is perfectly plain that this section can not exist in an agricultural sense without irrigation. With it, intelligent direction and steadiness of application will lead to abundant harvests even during the hot summer months. Certain small canals may possibly be maintained by the natural flow, but the limit is exceedingly small. The natural supply fostered and stored for an ever-flowing and constant distribution will, in this peculiarly favored climate, endow thousands of families with the attributes of prosperity, and delightful homes will spring like magic upon the now desolate and deserted plains. The omnipresent water thoroughly incorporated with the dormant elements of richness in the soil, will render prolific every acre that can be reached, and upon which the moisture can be maintained.

The lands described in this report possess all the requisite conditions for succe irrigation. The rivers furnish more than ample water during the largest portio the year, they have sufficient fall, the Gila averaging 4.5 feet per mile; the b are not too high, as they range between 4 and 18 feet; and finally, there is an a dance of fertile, gently sloping land upon which to carry the water. These la without irrigation, are absolutely valueless, but with proper storage and conduc facilities they will surely be worth not less than $200 per acre, the more espec when the healthful climate and the fact that grapes and citrus fruits ripen from month to six weeks earlier than the most favored part of California is taken consideration.

CANALS OF YUMA COUNTY.—Of the several large irrigation canals operatin Yuma County but one is completed. The remainder, while only partially finis are nevertheless in a position to meet the requirements of many acres of bottom valley lands, with the promise of extending their range of usefulness to many t as much again.

All head at some point or other upon the Gila River, and each is confined ent within the environs of the valley bearing the same name. The aggregate cost is great, but proportionate returns upon the invested capital will, for the first t become apparent during the coming twelve months. Canal building is of comp tively recent origin in the county. A few years since the fertile valleys were al literally destitute of human inhabitants, while to-day it is safe to say that e acre of valley land along the line of these canals has been filed upon, not to men considerable mesa land taken up along the line of their projected extensions. names of the most prominent water-ways, together with the length, carrying c city, estimated cost, and number of acres tributary to each, are given herewith.

Name of canals.	Length.	Capacity.	Estimated cost.	Numb acres claima
	Miles.	*Inches.*		
Mohawk	35	11.000	$150.000	40
Redondo	5	.600	8,000	1
Farmer's	13	5.000	15,000	10
South Gila	22	8.000	45,000	12
Purdy	10	9.000	25,000	7,
Contreras	7	3.000	9,000	2,
Saunder's	10	5.000	25,000	4.
Araby	8½	3.500	35,000	2,
Antelope	7	2.000	10,000	2.
Toltec	3	30.000	15,000	.....
Total	120½	77.100	337,000	81.

In the event of the completion of the above described works in accordance w the original plans of the projectors, the total length would reach 241 miles, reclai ing 267,000 acres of bottom, valley, and mesa land at an estimated cost of $1,318,0 The various works, commencing at Oatman Cañon and extending westerly at int vals to within a few miles of the Colorado River, do not, of course, cover all the aral land in the lower Gila Valley. With no Territorial laws upon the subject of irri tion and ownership of water, excepting the statute that the riparian doctrine shall b be recognized and that the prior locator shall hold as against all others, it has f lowed naturally that the first comers were the first served. Of the few available si for canal-headings, situated upon either side of the river, such as seemed likely prove the cheapest and most convenient during the periodic seasons of low water w taken up, leaving those that remained of little value until the time when water c be stored in sufficient quantities to render them of practical consequence.

The "duty" of water is not constant, but varies according to the locality. T quantity used per acre under the lower Gila Valley canals is rated at about one-thi of an inch. It should be explained that but little of the land has been irrigat earlier than eighteen months ago, and being virgin soil requires more water th what will be necessary during the coming seasons. For this reason it is fair to sume that the duty per inch will be materially increased. In California an inch w irrigate from 4 to 12 acres, and it is not only possible, but it is also likely, that t wasteful custom of applying more water to the soil than is actually needed in vog among the majority of Yuma County farmers may have much to do with the appare deficiency.

It may be stated incidentally that by irrigation the fertilization of land fluctua according to the nature and quantity of the silty matter deposited upon it by wate and this, it is estimated, is from 30 to 100 per cent. Both the Gila and the Colora

are especially rich in such matter, and therefore the constant fertilization effected through the operating canals renders any further enrichment of the soil superfluous, useless, and unnecessary.

WATER SUPPLY.—The original source of water supply is comprised in the fall of rain and snow in Arizona, and the States and Territories north and northeast of it, where the fall is greater than the evaporation, the water eventually finds its way to rivers and streams that drain the mountainous regions by seepage, percolation, and surface flow. It may also be taken from springs and wells fed similarly.

Water occurs in any portion of the Gila and Colorado Valleys at a depth of from 12 to 25 feet, but of course the quantity thus obtained is altogether inefficient for extensive irrigation. A few attempts were made to secure a flow from artesian wells, but thus far unsuccessfully. It is more than probable that sinking was in no instance prosecuted to commensurate depths, as the borings were in every case undertaken by private individuals. But, withal, the supply upon which the settlers are forced to place reliance is the inexhaustible volume that during high water passes along the channels of the Gila and Colorado Rivers to the sea. The drainage of much of Nevada, Utah, Colorado, and all of Arizona, finds lodgment in the Colorado throughout its 1,200 miles of channel. An admirable feature in this connection is the peculiarity of reaching its highest dimensions in the months of June and July, the very time when other streams are low. But it must be said that there is sufficient at all times to irrigate every acre of land tributary to it. The river supply at the season of irrigation is greater than that of all the utilized streams of California combined.

The Gila at certain annual periods spreads to close upon 2 miles where the surface contour so permits, with an average depth of 4 feet. In June, July, and August, for 60 miles from its mouth, it is either very low or absolutely dry, although considerable running water can always be found along the bed-rock. It happens frequently that where reefs of rock cross the river the water comes to the surface only to disappear in the thirsty sand on passing the barrier. An excellent site for storing enormous bodies of water has been surveyed by a competent engineer, the location being in the Gila Valley, a few miles east of the county line in Maricopa County. The hoarding capacity is in every way equal to furnishing irrigation facilities for the entire lower Gila Valley, as well as the outlying mesas and higher plains, while the construction will not be attended with unusual difficulties, nor would the cost prove excessive in comparison with the increased value of the lands tributary to it, much of which are now worthless. Such works would effectually obviate the disheartening effects of the sinking of water to bed-rock in summer, for the amount saved during high water that would otherwise have gone to waste would furnish the means of livelihood to a large population as against the present meager number.

The Colorado and Gila are included among the most prominent streams of the Pacific coast and afford far more than sufficient irrigation capacity for the cultivation of the rich areas included within the county lines. The former drains a catchment area of more than 242,000 square miles of mountainous country, while the latter also drains an immense surface very similar topographically. Thus it can easily be seen that water is superabundant. Whether the Government, with an overflowing Treasury and command over the most advanced engineering skill of the times, will utilize to the best advantage what is placed before it or not is a question that can be answered only by itself.

CLIMATE.—It is rather without the intents of this report to dwell in detail upon the sanitary advantages offered by our almost perfect climate, and yet a few words upon this subject may not be inappropriate. For nine out of twelve months the climate is simply superb. Three months are warm, but not excessively so, although the thermometer ranges far higher than would be conducive to health or comfort in any section of the East. The conditions, however, are most dissimilar, as may be seen by the following, taken from the official communication of Lieut. W. A. Glassford, of the United States Signal Corps, to the governor of the Territory:

"A few words upon the heat. It is recorded as extreme, yet no one suffers and sunstrokes are unknown. This is usually accounted for from purity and dryness of the air. Both are true, but the dryness is perhaps the correct reason. I have calculated the difference between the shade and sensible temperature at Yuma during the heated hour of the day, and it is about 30 degrees. At New York or Washington it is only a few degrees and often identical. The highest shade temperature ever recorded at Yuma is 118 degrees. When the heat is at this point the sensible temperature is about 88 degrees. The shade temperature of New York being 105 degrees the sensible temperature is certainly near 100 degrees. The difference between the mean temperature and mean sensible temperature for July is over 17 degrees at Yuma. These considerations of the sensible and shade temperature will account for the absence of any detrimental effect upon the extreme heat of Arizona.

"The air is dry; the moisture in the atmosphere is from 25 to 30 per cent. as against 75 to 85 per cent. in other localities. Every afternoon in summer there is a refreshing breeze from the Gulf of California that relieves the day of undesirable heat, it

passes over a desert, much of which is below sea-level, that acts as a desiccant, so that when the plains of Central Arizona are reached the air is dry to the last possible degree." There are neither sunstrokes in summer nor pneumonia in winter; neither fever nor malaria live or germinate in this section. The air is pure; absolutely free from those compounds that poison the system and bring on disease. In no country is there a greater number of bright nights and sunny days. Hundreds affected with lung trouble, after visiting Florida and southern California, have found relief in this invigorating climate, where the pure air is a tonic to shattered constitutions, a healing balsam to the consumptive. The meteorological conditions are indeed admirable for the cure of all rheumatic, bronchial, and pulmonary troubles, as has been proven time and time again. In summer the rapid evaporation lowers the temperature and promotes comfort, while in winter the mild, equable, and pleasant weather is delightful to the invalid. Herewith is given a table of average temperatures compiled from the official reports, extending over ten years:

	°		°
January	53.6	July	92.0
February	58.8	August	90.9
March	65.0	September	83.9
April	69.4	October	72.4
May	77.2	November	61.2
June	85.2	December	55.9

Concerning the effect in regard to early fruit the late commissioner of immigration Hon. Cameron H. King, already quoted in the preceding pages, has this to say, "The average spring, summer, and autumn temperature of Yuma are nearly 9 degrees more than at Riverside. This is sufficient to explain the fact that the citrus and other fruit of Yuma ripen from a month to six weeks earlier than at Riverside, or other points in southern California. Yuma has an earlier and warmer spring. The trees have an earlier start, and the higher temperature matures the fruit sooner. It is evident that since oranges in Yuma ripen in the first of December, instead of about the middle of January, as in southern California, that the fruit in Arizona can never be injured by any low temperature in the winter season. And since the labor of the tree is for the season practically over at Yuma before the winter season begins, it is better prepared to stand a lower temperature in winter than it could in California, even were the atmosphere as dry in the latter State as in Arizona. It is known that Riverside raises better oranges than Los Angeles, and the reason is that Riverside escapes the fogs which hang over Los Angeles.

"It is proper to observe that the maximums and minimums of temperature, as shown by the Signal Service records, indicate little of practical utility, since such extremes may not last more than a second, and may be the effect of one small wave or ripple of the air. The warm sunshine of the spring, summer, and autumn days causes the fruit in Yuma to mature early, and gives a delicious sweetness, flavor, and color to the orange, lime, lemon, and other citrus fruits, which they can not attain on the coast of the Pacific, where fogs dampen the fruit, mildew is produced, and dust coats both fruit and leaf. It is undeniable that nowhere upon the globe can a spot be found more favorable for the growth of citrus fruits than Yuma County."

The statement of the commissioner can be thoroughly substantiated, as may be seen by the annexed table showing the time of maturity for certain products:

Strawberries	January 15.
Apricots	April 1 to 21.
Mulberries	April 14 to 20.
Figs	April 20 to May 1.
Grapes	June 1 to 7.
Watermelons, etc	May 15 to 20.
Peaches	June 15.
Pomegranates	August 1.
Lemons	September 15 to 25.
Limes	September 15 to 25.
Dates	September 1 to 5.
Oranges	Nov. 25 to Dec. 1.

PRODUCTS.—Fruit culture has so far been prosecuted upon a limited scale, but enough has been learned from experimental tests to demonstrate the positive feasibility of not only producing an excellent quality of the most profitable fruit but also the ability to raise them for market three to six weeks earlier than any section of California. The orange, lemon, and lime, finding soils and climate congenial, yield in abundance large, clean-skinned, and exceedingly juicy fruit. They color handsomely, contain the requisite sweetness and acidity, and are very luscious.

The fig and pomegranate offer a character of fruit that almost stamp them as indigenous. The latter is not yet recognized to any great extent, but it will certainly

become an important factor in arboriculture when its economic qualities are better known.

As to the fig, the most desirable variety has yet to be determined. The true "white Smyrna" would probably prove the best, and that its yield would prove prodigious goes without saying. This assertion is a deduction based upon actual productive results of the "Mediterranean white" fig, that is known not to be the true Smyrna.

The grape seizes upon what is proffered to it and becomes hardy, thrifty, and adaptable. The choice naturally inclines to the earliest for table purposes. What those varieties should be is in process of experiment upon a scale that will soon solve the question, but it may be said that all kinds mature from three to four weeks before they do in California. They attain great size, cluster tightly on the bunches, are firm and highly colored, and possess exquisite flavor. Heavy wines and brandies of a super-excellent character can be made, but with light wines the reverse is true, for everything apparently goes to saccharine. For ripening wines the climatic conditions are admirable. A quantity of common white wine, costing 45 cents per gallon, was brought here from California by water years ago, and, on being found unsalable, was placed in cellars and its history almost forgotten. Nine years later the wine was brought to light, when it was discovered that it resembled a brown sherry, rich in boquet, smooth as oil, and delicious to the taste. It was carefully drawn from the casks, bottled, and sold at $2.50 per bottle.

The olive grows luxuriantly and will in the future become a most profitable investment. Whatever its characteristics elsewhere, here it requires water and cultivation; the more water the better. The mulberry grows rapidly, and when firmly rooted vigorously withstands the heat and lack of water. It produces an early, large, and sweet fruit, and is a highly desirable tree to plant along the canals for its grateful shade.

The plum can easily be raised from the seed. It fruits early, though so far the product does not commend itself particularly for table use, but as a stock upon which to engraft prunes, or even superior varieties of plums, it is everything to be desired. An experiment in this line with the best prune known in California showed a growth of 23 inches in forty days from the insertion of the graft.

The date has passed beyond conjecture. The plant produces magnificently, and its cultivation will be prosecuted more extensively this winter than ever before. The soil is in every way suitable, and with occasional cultivation and intelligent irrigation a quick and permanent growth is assured.

Apricots and peaches have been tested. They mature rapidly, bear choice fruit, and are always healthy, giving flattering indications of future success.

As facilities increase other fruit trees will be introduced, and with the same care that is bestowed upon them elsewhere will so soon as they become acclimated come to a yield materially in advance of the places from whence they came. The field is too large to admit of extended comment at this time, but it may suffice to refer briefly to certain other products which may in time equal if not surpass fruit-growing as a commercial proposition—as, for example, cotton, wild hemp, ramie, sugar-cane, sugar beets, etc. Cotton has been tried from time to time for years with varying but always satisfactory results, and even then without care. If watered regularly it becomes a large bush, and if properly pruned a tree, being in flower, boll and cotton, the year round. These bushes and trees have in instances borne steadily for fourteen years. The staple of course diminishes in course of time, but at ten years it is not inferior to the average staple of Western India.

Wild hemp is a textile plant indigenous to the country. It grows freely and luxuriously to a great height, often averaging 15 to 17 feet. It has a long strong fiber and is frequently worked into nets and fishing-lines by the Yuma Indians. Convulsive attempts have been made to utilize this plant, with the practical result of fixing its value, among the fibers used in the manufacture of cordage, at about $160 per ton of 2,000 pounds. After proper bleaching and manipulation a beautiful fiber has been produced and manufactured into colored fabrics, taking the dye, retaining the elasticity and luster, exactly as well as the fabrics of true flax and ramie. It seeds itself annually, and immediately following the overflows of the Colorado River takes possession of every nook, corner, and open area, to the exclusion of everything else. It covers not less than 100 square miles in an unbroken stretch, commencing near the boundary line of the Gadsen purchase and extending southwards along the river to Hardy's, Colorado, below the point where the rising tides of the Gulf of California force back the flow of the Colorado River proper.

The fibrous plant ramie has been given a partial trial. The soil, on analysis, was found to contain all the essential properties to render the most favorable results, but the absence of water, together with injudiciously planting the roots too late, retarded the growth. Enough data was obtained, however, to warrant the belief that this will eventually become one of our most important industries. Sugar-cane has been fairly tested with the Sonora cane. The growth was surprisingly great and the percentage of juice much increased over the yield at the place from which it was

originally brought. A superior quality of panocha and sirup was manufactured, the prices realized leaving handsome margins for profit. The capriciousness of the water supply, as in the case of ramie, dissolved the industry, and it has not since been revived.

The sugar beet promises better results for the future than many of the products already mentioned as prominent in the same direction. Samples not fully matured polarized 17 per cent. With proper cultivation the percentage can be raised to 20 per cent. and 25 per cent., and, besides, will harvest two crops each year.

Wheat does splendidly, but complete data is not at hand from which to compute the average yield. In one instance, however, 483 pounds seeded to 20 acres, about 9 miles east of Yuma, on the Gila River, returned 52,750 pounds after being irrigated five times. This was sold in San Francisco, bringing 50 cents the cental over every other kind then in the market. The grain is remarkable for its plump berry-like appearance. The winter and spring are warm enough to insure a vigorous growth and yet cool enough in April and May to allow the heads to fill out without shriveling. It is so perfect as to sell for seed, and, so far as known, is proof against rust. Two crops are raised annually.

Barley also does well and will produce two crops, the first yielding from 35 to 40 bushels of barley, and the second a large amount of hay.

Corn is produced in great quantity, yields enormously, and can be grown the year round. The "Cocopah" corn is noted for sweetness, plumpness, earliness, and for its firm and solid grains. Five weeks after planting roasting-ears are plentiful. This variety commands a ready sale at higher prices than any other kind.

Alfalfa will cut from five to seven times, at an average of 2½ tons to the acre. Eight acres, but one year old, has this year yielded 74 tons, with more cuttings yet to be made. The hay brings $15 per ton. Sorghum, raised for feed, is both valuable and prolific. It frequently reaches 15 feet in height, yields 15 to 20 tons per acre, and is worth $15 per ton. Several crops can be harvested annually.

Vegetables, kitchen and garden stuff, melons, etc., grow all the year in unlimited quantities and of excellent quality. Sometime since a Gila valley farmer planted 15 pounds of Irish potatoes on a piece of bottom land that had been overflowed, from which he harvested over 760 pounds, and this record, it is believed, has rarely, if ever, been excelled. The sweet potato produces enormously, and equals the choicest from South Carolina. Peanuts mature rapidly and abundantly, yielding a nut both plump and toothsome.

Wherever there is sufficient moisture the natural flora abound in profusion and variety. They are of rare beauty and delicious fragrance, the bulbous plants particularly. The lily surpasses the famous imported "Japan." It has been claimed by experts that at no distant period opium will be manufactured from the poppy and attar from roses, both flowers thriving vigorously. There are but few trees and shrubs, capable of adorning the surroundings of a lovely modern home, that can not be satisfactorily grown.

Every plant, vine, or tree mentioned in the foregoing list has been actually proven adaptable to our soils and climate. Many others have been omitted through lack of space, but there seems no doubt that time will demonstrate our ability to profitably raise all the semi-tropic and most of the tropical and temperate productions.

TRANSPORTATION.—An important factor in connection with the early ripening of horticultural, vinticultural, and agricultural products, is the question of easy and rapid conveyance to prominent marketing centers east and west. The Southern Pacific Railroad, one of the largest transcontinental lines in America, runs through the Gila Valley as far as Adonde, a station some 30 miles east of Yuma. It then passes upon the mesas south of the Gila, the track extending upon an average not more than 5 miles from the river, until the county line is reached. Thus is afforded convenient egress from any section of the valley and direct communication from thence with all parts of the United States.

Other roads have been surveyed along both sides of the river. Construction is already commenced on the direct broad-gauge from San Diego to Yuma, and will, it is expected, be continued from the latter town to Deming, N. Mex., but nothing definite can be advanced as to the time of completion.

OATMAN CAÑON RESERVOIR SITE.—It is quite apparent that more water is needed in the summer months than flows in the Gila River during the heated term. In view of remedying the deficiency, a site for an immense storage reservoir was located, and an engineer engaged to examine and report upon its adaptability. Mr. J. B. Steiger, the engineer in charge of the work, has submitted the following report to the local committee:

To the Committee on Storage Reservoir Sites for Yuma County, Ariz.:

GENTLEMEN: In accordance with your instructions, I have made a reconnaissance survey of the proposed water storage reservoir on the Gila River at Oatman and Cottonwood Flats, and summit the following report on the same: The most available site for a dam 100 feet in height is at a point on the river about half a mile above the

South Gila Canal Company's head-gate. Solid bluffs of dolomite (limestone) 111 to 125 feet above the present water-level, and distant 1,595 feet from each other, are found at this point. The width of 1,595 feet given is the distance between the bluffs at the 100-foot flow-line, or proposed top of dam. The storage capacity of the cañon extending about 1½ miles up the river from the dam to Oatman Flat is comparatively small, for the average width on the 100-foot flow-line is but one-half a mile, with steep bluffs on either side.

Above this one-half mile point the bottoms widen out to an average width of 1½ miles for 3 miles, forming what is called Oatman Flat, with an area of 4.7 square miles on the 100-foot contour. At the head of Oatman Flat the bottoms narrow to about three-quarters of a mile, and then widen out and form Cottonwood Flat, the main storage basin, with a length of 8 miles and a width of 4½ miles, with an area of 35.2 square miles. About 2 miles above the head of Cottonwood Flat, at Rock Islands, the bottom narrows to a width of about 2,000 feet, including an island 500 feet wide, and above this point they again widen to 3 miles. The length of this basin will be 8½ miles, with an area of 8½ square miles.

The depth of the water at the lower Rock Island will be 40 feet. The average fall in the river from this point to the dam, some 14 miles by the river channel, is 4.3 feet per mile. The river has a much greater grade above the Rock Islands.

The distance from the islands to Gila Bend is about 20 miles. The total area of the three basins is as follows:

	Square miles.
Oatman Flat	4.7
Cottonwood Flat	35.2
Gila Bend Flat	8.5
Total flowage (with 100-foot dam)	48.4

As there will be considerable evaporation from a body of water in this hot summer climate, estimated at half an inch a day for six months, equal to 7½ feet, I assume the average available depth to be 35 feet, which with an area of 48.4 square miles will store 47,227,009,600 cubic feet. This will give a daily supply for six months of 262,372,200 cubic feet, equal to 151,835 miners' inches of the California standard.

The area which it is proposed to flood contains no cultivated land and only three cattle ranches.

J. B. STEIGER, *C. E.*

YUMA COUNTY, ARIZ., *August* 7, 1889.

The proposed storage reservoir is situated on the Gila River about 100 miles northeast of the town of Yuma, and a few miles east of the boundary line of the county. At this point the river is subject to heavy floods that will insure the filling of the reservoir every winter and spring, the heavy flow lasting until the 1st of May.

About the 1st of June the works would be called upon to make good the diminishing supply in the Gila. This draft would be at its maximum in July and August. The evaporation in this climate is very great but the engineer has allowed amply for the losses thereby incurred. The depth of evaporation in inches averaged for every month in the year, as shown by the Signal Service records at Yuma, is as follows:

	Inches.		Inches.
January	4.4	August	10.2
February	5.2	September	8.2
March	6.6	October	8.2
April	9.6	November	5.5
May	9.6	December	4.6
June	12.6		
July	11.0	Total	95.7

The rainfall is practically insignificant. The monthly fall in inches, averaged for eleven years, is given herewith:

	Inches.		Inches
January	0.403	August	0.496
February	0.532	September	0.060
March	0.217	October	0.124
April	0.120	November	0.180
May	0.062	December	0.403
June	Inappreciable		
July	0.155	Total	2.752

The drainage basin supplying the river is known to be enormous and its service constant during certain months. At the lowest rate of calculation in use in California—inch to 4 acres—the amount of water stored would suffice to irrigate over 600,000

acres. Rock suitable for the construction of a masonry dam is found in unli quantities adjacent to the proposed site. Elsewhere we have endeavored to that large and constant water supplies are imperatively needed. While it i that the several canals along the Gila cover considerable areas, it is also true th Oatman Cañon reservoir will bring very much larger tracts under control, and, fore, an increased population, much larger property valuation, vastly augment ricultural output, and, consequently greater prosperity. With storage works described capacity a permanent summer supply of water could be relied upon to oughly irrigate most of the accessible arable land in southern Yuma County lyi low the reservoir, and thus remove the present cause of non-development of this section. It has been explained that about 25 per cent. of the valley land is overf by the river during certain regular periods. The establishment of such works also reclaim the bottoms by storing the surplus water that would otherwise flo surface.

CONCLUSION.—With this report a topographical map, drawn by Mr. Lev Hicks, C. E., is submitted, showing the entire lower Gila Valley from Oatman westward to the Colorado River, and also all the lands between the Gila and the Sonora frontier. Two lines are drawn, the first indicating the extent area that would be capable of producing at least one crop of cereals or forage year, supposing the dam to contain 25 feet of water. This second line sho limit of the fruit belt, but the area between these two lines will be valuable f raising of all forage plants, sugar-beets, etc. Below their junction all the shown will be available. The varied topographical features are faithfully a telligently delineated and will greatly assist in a correct understanding of th ject treated in these pages.

The vast importance of the inquiries set in motion by the Senatorial comm and their direct bearing upon our own surroundings, are fully understood by the of Yuma County, who highly appreciate the opportunity of placing before the tinguished visitors such data concerning the quantity and quality of the land necessity and future possibilities of irrigation, the number and extent of canal rivers and water supply, the climate and its influence upon the early matur crops, the products, the transportation facilities, and finally, the need of water-st reservoirs and selection of appropriate sites as, it is hoped, may meet their pur If this has been accomplished, the citizens' executive committee will consider duty as satisfactorily performed.

STATEMENT OF HENRY GEORGE, UNITED STATES INDIAN AG OF PARKER, ARIZ.

[Colorado River Indian Agency.]

That the valley or bottom lands of the Colorado River, pro watered, can be made one of the finest farming sections of the U States, I presume is no longer a question among those who hav vestigated the subject.

In the Annual Report of Indian Affairs in Arizona, 1867, I find following:

The experiences of this season have proved beyond doubt, were evidence o subject still wanting, the thorough capability of the lands of the Colorado Riv ley for all the purposes of agriculture in every case where water can be made to the surface. To depend upon the annual overflow is somewhat hazardous, for reached by it one year may not be again for several, or they may be so deeply merged as to be unavailable for planting during the season. There are thous acres in the reservation which the overflow from the river never reaches, but the artificial application of water would render as productive as any of the that are naturally overflowed.

All experience from that time up to the present proves the co ness of the ideas of that paragraph.

The custom of irrigation in vogue on the reservation is carrying by hand from the river and lagunas. The Indians select their loca for their small farms, or rather patches, near the banks of the riv some laguna. After choosing the land they dig holes about 12 in

deep and from 15 inches to 6 or 8 feet apart, owing to the kind of crop. In the bottom of these holes they plant their corn, wheat, pumpkins, and various kinds of melons. Into these holes, which serve as a basin to hold moisture, they pour the water. The quantity and quality of the products the Indians thus produce are remarkable. They do not, however, all depend on this kind of irrigation for a crop; some of them select low places in swags near the river which is sufficiently moistened by sepoge water from the river to grow their crops. I never saw better wheat grown in any country than I have seen in these swags.

The surface of the valley or bottom lands along the Colorado River seems to be from 8 to 20 feet above the ordinary stage of water in the river, and it is said that the river falls but a little over 2 feet to the mile. You can see that it would be very hard indeed to conduct the water from the bed of the river to the surface of the valley, I should think. I am not familiar with the science of the subject. However, in order to bring water from the bed of the river by canal so it can be utilized on the surface in the valley, the head of the canal must be located at least 12 miles above the lands to be irrigated. Owing to the soft sandy formation of the banks the channel of the river is continually changing, which will be a very serious obstacle in bringing water out with the ordinary canal or ditch. There is always abundance of sand and dirt floating in the water, and when the river is high there is so much floating that it seems to me that it would be very hard to prevent the sediment from filling a canal with only 1 or 1½ foot fall to the mile. But if they had any such experience with the canal that was constructed here in the latter part of the sixties, I have not been able to find it out.

The engineering of the location of the canal was certainly good. I doubt if there is a better place on the river for a head-gate. From the Arizona side there is a spur of nearly solid stone formation, extending out in a curve to nearly the center of the river, thus forming a basin in which I am informed no sediment has ever settled. In the arc of the curve of this basin the head-gate is located. A tunnel was made several hundred feet through a hill out to the foot of a mesa and on to the valley 5 or 6 miles below. I understand the canal was used successfully until the tunnel gave way near the head-gate, after which there was a temporary gate made lower down the river below the tunnel, that will conduct water into the ditch when the river is high. There have been several overflows over the canal and yet it stands intact, and with a very little work, removing some brush and other obstruction, it would conduct the water well. This canal brought water sufficiently high to be thrown out on the surface in less than 6 miles below the head-gate. Of course the canal, with a fall of only about 1 foot to the mile, had to have careful attention, keeping all obstructions removed, and occasionally had to be cleaned out; but I understand this did not have to be done more than once in twelve months.

I have said the head-gate and canal were admirably located, but there was some ridiculous judgment displayed in the work on the canal. The formation through which the tunnel was cut is of pebbles and a kind of cement-looking sand, and when dry presents a hard appearance but yields quickly to running water. Into this, without any kind of masonry work, the water was turned; the walls gave way, and thousands of dollars' worth of work was destroyed, and with it went the hopes of a dry arid valley being changed into a luxuriant farming section. If the proper masonry work had been done in the tunnel, there

is no doubt in my mind but what the canal would have been a success, and to-day thousands of acres of this valley would be blooming fields.

Some of the whites have attempted to irrigate by pumping water by steam power, but while they can in that way get water into a ditch with sufficient fall and do excellent work, the experience with this mode of irrigation, so far as I have been able to learn, is that it is too expensive to be profitable, but some of the best posted people in the valley contend that there has never been a fair test made, and that it is the best plan and can be made successful.

PHŒNIX, ARIZ., *September* 4, 1889.

The committee met pursuant to the call of the chairman.

Present, Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF T. E. FARISH, OF PHŒNIX.

The CHAIRMAN. What is your occupation?

Mr. FARISH. Commissioner of emigration.

The CHAIRMAN. What do you know of irrigation in Arizona? What has been its success and what are the opportunities for doing more?

Mr. FARISH. Do you wish me to cover the whole Territory?

The CHAIRMAN. Yes, or any part with which you are familiar.

Mr. FARISH. In this Territory, the report which I have written and which will be submitted to the committee will show that there are 250,000 acres of land now covered by irrigating canals, 187,500 acres of which have been reclaimed; that is to say, the land has been covered by the water; and 125,000 acres, about one-half, is in actual cultivation all the time. The report and the maps accompanying it will further show that that statement applies to the Salt River, and that in the Gila River Valley there have been works undertaken, and there canals are now in process of construction, where 30,000 acres are under cultivation. When those canals shall have been completed, there will be added 150,000 or 200,000 acres more.

Examinations made by Mr. Breckenbridge, our county surveyor, show that up at the head of the Salt River, where it enters into this county, and adjoining the Gila, there can be a reservoir constructed that will impound enough water to irrigate all the land lying north of the Gila River in this valley, and through the Salt River valley down to Yuma.

Senator REAGAN. Have you made an estimate of what that is?

Mr. FARISH. The figures are stated in the report which will be submitted to the committee. Mr. Evans has it. I do not remember the exact figures. As to the duty of water in this county, we irrigate alfalfa and grain, and it takes 3 acres of ground to 1 miner's inch.

The CHAIRMAN. Is 1 miner's inch one-fiftieth of a cubic foot per second?

Mr. FARISH. We calculate it to be one-fortieth.

The CHAIRMAN. Calculating it that way, a miner's inch will serve 3 acres.

Mr. FARISH. Three acres. In fruits and vines, 5 acres. The evaporation here is large during the summer months; but what it is during the winter I can not tell you, because the only data that has been kept *so far has* been at Tempe for the last two months. It was 4.2 evaporation in August.

Director POWELL. Four and two-tenths what?

Mr. FARISH. Four and two-tenths per cent., nearly half an inch.

Director POWELL. In what time?

Mr. FARISH. In twenty-four hours. At Walnut Grove—I only speak of what I have learned in corresponding with that point—where they have the big irrigation dam, it is about 3,500 feet elevation, and the evaporation is about a third of an inch. Here we have 1,180 feet, and I suppose about the same at Tempe, but at Walnut Grove they are 3,500 feet.

The CHAIRMAN. Is that the evaporation in twenty-four hours?

Mr. FARISH. Yes.

The CHAIRMAN. You said that dams could be constructed to reclaim all the valley land between here and Yuma. Is there sufficient supply of water for that purpose?

Mr. FARISH. I think so. Data will be furnished the committee showing the amount of water which flows to the sea unharnessed during the year. The data has been kept by the Arizona Canal Company, and it will show you that during several months of the season it is as high as 40,000 cubic feet per second. It would fill the dam to the top four times over. During the winter you can not cross Salt River at any time from four to six weeks in succession.

The CHAIRMAN. With a team?

Mr. FARISH. With a team. Nor can you be ferried across; it is a mountain torrent.

The CHAIRMAN. What is the fall in the Salt River?

Mr. FARISH. The fall is very small. It can not be large. Tempe is above this place. It is a little over 100 feet.

The CHAIRMAN. In 10 miles it is 100 feet?

Mr. FARISH. It is not over 25 to 30 feet higher, and the difference between the altitude of Yuma and this place is about 1,000 feet.

The CHAIRMAN. What is the distance?

Mr. FARISH. I think something over 186 miles. Then, in this county, up above Florence about 20 miles, there is a natural reservoir where you can impound a great deal of water. The Florence Canal Company is prepared to put in a dam to reclaim some 200,000 to 300,000 acres. The experience in this valley has been that the more irrigation the more land susceptible of cultivation. The policy among our farmers of late years has been, in the winter when water is plentiful, to flood the lands, to give them all the water they will stand. That creates a reservoir by absorption, which supplies the water during the dry season. There is another feature about it. There is more water now flowing through the Salt River during the dry months of June, July, and August than there was before a canal was dug in this valley.

Senator REAGAN. How do you account for it?

Mr. FARISH. By the ground absorbing the water. The water percolates back into the stream, and finds its natural channel. Then there is a good deal of land where you can grow alfalfa, fruits, and vegetables without irrigation.

The CHAIRMAN. That is without surface irrigation.

Mr. FARISH. Yes; it has sub-irrigation. It is the natural slope which brings the water down and keeps the soil forever moist. My theory is that when the land is covered by raising the canal, really a high-land canal, and all the lands under it are in cultivation, there will be some lands in the lower part of the valley that will require drainage.

The CHAIRMAN. Drainage is often an important matter, because alkali may form on the land for want of drainage.

Mr. FARISH. I have not heard of any alkali forming. I do not believe there is any such thing existing in this county. Another feature of this county is this: Up here in the Verde there is in the lowest water season several inches of water that flows into the plain in sinks. There are traces here of old canals built by the ancients; canals as large as the Arizona Canal. By building a reservoir up that stream there could be 75,000 acres reclaimed under it.

The CHAIRMAN. Are the places suitable for reservoir sites upon public or private land?

Mr. FARISH. Some are located upon public land, and some are not.

The CHAIRMAN. I do not mean the location of the reservoir. Are there settlers upon the land?

Mr. FARISH. There are along this large canal of which I spoke, the one that would reclaim so much land, extending down to Yuma.

The CHAIRMAN. How many acres are located?

Mr. FARISH. Six thousand acres are located.

The CHAIRMAN. Located since last October?

Mr. FARISH. No; before. There are some 3,000 or 4,000 acres that have been in cultivation for the last two years.

The CHAIRMAN. Have you a law on the statute-book under which you can condemn land for purposes of reservoirs?

Mr. FARISH. No; we have not.

The CHAIRMAN. How are the other places for reservoirs?

Mr. FARISH. I think within this county that about covers all of it, because we do not want more.

THE CHAIRMAN. You spoke of several reservoir sites. Are they on public land?

Mr. FARISH. Yes; they are on public land. In Yavapai County there is the largest water storage concern that there is. I can give you the dimensions.

The CHAIRMAN. Does this all appear in your report?

Mr. FARISH. No; only for this county.

The CHAIRMAN. Has anybody made up a report for the whole Territory?

Mr. FARISH. No.

The CHAIRMAN. Has the surveyor-general any knowledge of it?

Mr. FARISH. There is no surveyor-general in the Territory. I can give you such information as has reached me as commissioner of emigration. If you wish me to go into Yavapai County I can do so. They have built a large storage reservoir there which is calculated to reclaim from 25,000 to 30,000 acres. There have been dam sites utilized at Date Creek and Bill Williams Fork, which are intended to reclaim about 50,000 acres. In Big and Little Cheyenne valleys there could be reclaimed probably 10,000 or 15,000 acres.

Senator REAGAN. Where are they.

Mr. FARISH. In Yavapai County. Along the Rio Verde there are reclaimed already 30,000 acres, which can be more than doubled by using the entire water supply. In other valleys there could be reclaimed some 25,000 acres. In Apaché County there is under cultivation about 20,000 acres, and there could be reclaimed by water storage reservoirs on the streams making out from the mountains about 150,000 acres. In Graham County, along the Gila, it is estimated that there are about 30,000 or 40,000 acres under cultivation.

The CHAIRMAN. Is that below here?

Mr. FARISH. That is above here, one of the northern counties. That could be doubled under cultivation by utilizing all the water of the Gila.

In Cochise County there is under cultivation along the San Pedro 35,000 acres. This could be increased to 75,000 acres by proper utilization of the waters of that stream. In the valley and plain of the San Simon where waters reach into the valleys by different streams, by the utilization of those waters there could be reclaimed I do not know how much—15,000 or 20,000 acres. There are a good many gardens, and on the Whetstone there could be a reservoir for the reclamation of a large amount of land, and on the adjacent plains how much I could not tell you. The Sulphur Springs Valley contains, I think, by an actual survey, some 83,000 acres. The water underlies the surface from a depth of 15 to 20 feet. Wells have been dug all through that valley, and I believe by pumping all that land can be brought under irrigagation. I simply give this as an off-hand opinion. But in 1879 when I first went over that valley there was not a hoof of stock on it, and now it is all eaten down. In the upper Gila Valley there is not a great deal of land susceptible of reclamation, probably not over 10,000 or 15,000 acres. In Pima County there are at least 8,000 acres—I have forgotten the precise number, but the possibilities there of water storage and irrigation are very great.

At Pantano there is a natural place for a reservoir, and there you could store water enough to reclaim 150,000 or 200,000 acres of land. There is enough water flowing down the Santa Cruz, where a reservoir could be constructed, to reclaim a large amount of land—from that on down to Tucson. The Santa Cruz River sinks some miles below Tucson, and is supposed to find its way back to the Gila at Florence. If its channel could be found, there would be a proper place to dig artesian wells. In the mountains near Florence there could be reclaimed by water storage by a reservoir above the Gila Buttes—15 or 20 miles above the canal—about 160,000 acres of land lying in Pinal County. By damming the Gila water with stone abutments, the river there having a channel 15 feet wide—the dam being 200 feet high—the water could be backed up 20 miles at that point, and you could impound water enough to reclaim from 300,000 to 400,000 acres of land. That, in connection with the big dam over on the Salt River, reclaiming the land of which I have previously spoken, and with the other reservoirs on the Lower Gila, which the map will show, and also those on the Rio Verde in this county, there could be reclaimed perhaps from Pinal County on to Yuma 3,000,000 or 4,000,000 acres of land. And of that land I wish to say here there is no better anywhere on the face of the continent.

The CHAIRMAN. What crops will it produce?

Mr. FARISH. Cereals, and fruits and vegetables of all kinds.

The CHAIRMAN. What kind of fruits?

Mr. FARISH. As fine lemons as you would wish. Along at Florence they have grown splendid olives. In this valley our olive trees are not far enough advanced to tell anything about; but they have grown them up there. We have planted out here some 22,000 orange trees, experiments in growing that have been successful. We think we have a field here for growing oranges. Peaches, pears, and apples are not so good in this part of the Territory. They grow to great perfection so far as size is concerned, but they lack flavor. We grow the crab-apple, prunes, and dates. Every variety of fig is a natural product here. The date is produced here, seven years from the seed.

Senator REAGAN. You mean that the tree bears in that time?

Mr. FARISH. Yes; and in bunches of from 5 to 25 pounds. And we grow wheat here—I should think about 1,800 to 2,000 pounds to the

acre. The yield of barley is from 2,000 to 2,500 pounds to the acre, and sometimes as high as 3,000 and 4,000 pounds. Alfalfa is the principal crop. We cut that from three to four times a year, and we cut from 6 to 8 tons to the acre. Now, I think I have gone over the whole Territory, and any questions which you have to ask I would be glad to answer.

The CHAIRMAN. What advantage, if any, would it be to have the Government make surveys and designate the lines of ditches and sites for reservoirs, and make estimates of the cost of constructing the works, with an estimate of the amount of land that could be redeemed.

Mr. FARISH. That would be a very great advantage, provided the work was not followed up by a restrictive clause that no entry could be made——

The CHAIRMAN. I did not ask you that question.

Mr. FARISH. All right. It would be a very great advantage. I wanted to follow the one with the other, because I do not think it would be of any great advantage unless the arid lands were left where they were before the passage of such a bill.

The CHAIRMAN. You do not think the reservation of reservoir sites, the designation of lines of ditches, estimates of the cost of constructing them, the amount of land to be reclaimed, and with the land thrown open to settlers by proclamation, would be of any advantage?

Mr. FARISH. I do not think they would be of any great advantage, because that clause is restrictive. You can not do that work under such circumstances through united enterprise. If the Government could build those reservoirs it would be all right. It could then say to anybody, come in. But you are restricted to a homestead entry of 160 acres.

The CHAIRMAN. How many men in this county cultivate well and to their highest capacity 640 acres of land?

Mr. FARISH. I do not believe there are any.

The CHAIRMAN. How much land in this Territory could a farmer with his family cultivate to its highest capacity, and get the best results without hiring labor?

Mr. FARISH. I understand your idea. But that question would not apply to all this Territory.

The CHAIRMAN. I mean the part that has to be irrigated.

Mr. FARISH. You could not go to work and pass a general law, one that would be applicable to every portion of this Territory with equal force, because the products of the north are different from those of the south.

The CHAIRMAN. Let us take it by sections. Take the valley from here down to Yuma. How much land can a man cultivate, raise fruits and all-round crops, and get the best results from the land?

Mr. FARISH. That would depend upon the kind of products. If grain, it would be one thing; if fruits it would be another. If alfalfa it would be another, because alfalfa requires nothing but three or four irrigations a year. But if a man wanted to get the highest products, and the railroad facilities were such as to give him a market, then, of course, horticulture would be his forte, because land planted in fruits would yield a higher percentage than anything else. Therefore, I would say that 15 or 20 acres would be as much land as he could attend to. If, however, it were in alfalfa he could attend to 320 acres.

The CHAIRMAN. Did you ever know a community to be wealthy and prosperous that cultivated but one crop?

Mr. FARISH. You are now asking me about matters that I have not

looked into. But, I do not think any community that cultivated but one crop was ever prosperous. To go back to my first remark, that law is restrictive so far as the prosperity of Arizona is concerned. I think the interest of the Territory is identical with that of the Government—to have the public lands made productive and made to bear their proportion of the burdens of taxation.

Mr. Farish filed at a later date with the committee the following data, compiled from the records of his office, that of Territorial commissioner of emigration:

RESOURCES, LAND VALUES, POPULATION, AND PRODUCTS.

The population of Arizona is rapidly increasing, especially in the southwestern and central portions of the Territory. The immigration into these sections aggregates 5,000 persons yearly, and the increase for the Territory for the last ten years will average fully 10,000 per annum. Our mining industries are being rapidly developed. Several large producing mines have been opened the present year, of which the Yuma copper mine, the Standard and Harqua Hala gold mines, are the most prominent. Large enterprises are being undertaken in irrigation that will more than double the arable land of the Territory in the next three years. The construction of a north and south railroad, connecting the Atlantic and the Pacific and the Southern Pacific by the way of Prescott and Phœnix, will open up a great mineral country heretofore inaccessible, create a home market for the lumber of the north, and give an outlet for the products of the Gila and Salt River Valleys in northern Arizona, New Mexico, and Colorado.

The returns from the different counties to the Territorial auditor for the present year show a total valuation of $27,231,424.47. But this does not represent the cash value of the property of the Territory, for no species of property pays on more than one-third its value.

In valuation on land the disproportion is even greater. Arable land with water that sells at from $20 to $75 per acre is assessed at from $5 to $15 per acre. There are assessed 5,985,358 acres in the Territory, about 5,000,000 of which is embraced in the grant to Atlantic and Pacific Railroad, and assessed at 20 cents per acre, which is being sold at from $1 to $10 per acre. The entire valuation on land is $3,285,212.60, on landed improvements, $1,931,440.83. There are assessed 552,718 head of cattle; the actual number in the Territory will fall a little short of 2,000,000. We market more than 300,000 beef steers yearly. These explanations are necessary to an understanding of the real property values of Arizona, which at a conservative estimate will reach $75,000,000. The expenses of the Territorial government, as estimated by the board of equalization for the ensuing year, is $180,000, which includes interest on bonded and floating debt, sinking fund, support of prison asylum, normal school, salaries of Territorial officers, and all incidental expenses.

The estimated population is by counties as follows:

Yavapai	16,000	Cochise	14,000
Maricopa	16,000	Pima	14,000
Apache	12,000	Pinal	8,000
Mohave	5,000	Yuma	3,000
Gila	5,000		
Graham	12,000	Total	105,000

The lands covered by canals and ditches is in—

	Acres.		Acres.
Apache County	6,900	Yuma County	40,000
Yavapai County	40,360	Pima County	7,500
Gila County	7,600	Cochise County	23,500
Pinal County	71,600	Mohave County	1,000
Graham County	47,000		
Maricopa County	321,000	Total	566,460

Of land requiring no irrtgation the amount entered and occupied is estimated at 100,000 acres, lying principally in the counties of Apache, Yavapai, Graham, Pima, and Cochise, of which one-half has been cropped the present season. The number of acres of irrigable land cultivated this year is by counties as follows:

	Acres.		Acres.
Apache	6,900	Cochise	18,000
Yavapai	10,000	Mohave	1,000
Gila	7,000		256,900
Pinal	17,000	Of non-irrigable land	50,000
Graham	35,000		
Maricopa	150,000	Total	306,900
Yuma	6,000		
Pima	6,000		

This quantity will be increased the ensuing year by the addition of 75,000 acres, the most of which will be in the Gila and Salt River Valleys from Florence to Yuma.

The value of the agricultural product varies according to locality. In this valley the Salt River hay is baled at $5 per ton; in Yavapai and Apache Counties at $20 to $25. Barley is worth here 75 cents per hundred; in other counties from $1 to $2.50. Fruit here is worth from $20 to $40 per ton; in other counties from $40 to $200. Land in alfalfa or grain here gives a return of from $15 to $25 per acre; in other counties from $30 to $50. Fruit in this and the Gila Valleys give a return of $100 to $200 per acre, and in other localities more or less according to yield. The value of product from every acre of land cultivated in Arizona can safely be placed at $30, which will be largely increased in the southern valleys as the orange, fig, grape, apricot, and other fruit trees and vines now being planted come into bearing.

The value of the products of the Territory for this year is as follows:

Agricultural and horticultural	$9,207,000
Live stock, horses, sheep, and cattle	6,000,000
Gold and silver	4,431,500
Copper	2,000,000
Lumber, wool, etc.	1,500,000
Total	23,138,500

The great need of Arizona is railroad connections, roads that would make a market for her coal measures, and make available her extensive lumber forests that cover with juniper, spruce, and pine 20,000 square miles of her territory, extending from the Santa Rita and Chiracbua Mountains in the south, northwest to the Nevada line, in which are mountain parks, where wheat, oats, and all root vegetables can be grown without irrigation. There is a million of acres upon which crops can be grown without irrigation, which will be settled as soon as railroads make accessible markets.

In the Territory the amount of land that can be reclaimed through a proper system of reservoirs and canals, conserving the storm-water for irrigation, is very large, being variously estimated from 6,000,000 to 8,000,000 of acres, fully two-thirds of which, lying below the thirty-fourth parallel and not in the mountains, can be made available for the cultivation of those citrus and deciduous fruits that make horticulture most profitable in all semi-tropical countries.

Since the removal of hostile Apaches from our borders, Arizona has made rapid development, and none of the Western States or Territories has, apparently, a brighter future before them. She has all the conditions to support a dense population, and a citizenship that unrestricted will make those conditions available.

STATEMENT OF W. J. MURPHY, OF PHŒNIX.

The CHAIRMAN. How long have you resided in Phœnix?

Mr. MURPHY. Seven years.

The CHAIRMAN. What is your occupation?

Mr. MURPHY. Railroad builder and contractor.

The CHAIRMAN. Have you inquired into the effects of irrigation in this portion of the Territory?

Mr. MURPHY. Yes, some. I have made some observations of the result of irrigation.

The CHAIRMAN. State the amount of land that can be irrigated and the sources of water supply.

Mr. MURPHY. I am not familiar with the Territory outside of this county.

The CHAIRMAN. Then confine your statement to this county.

Mr. MURPHY. The amount of land now under cultivation is, in round figures, about 100,000 acres; that is, under irrigation. There are in this county, in the Salt River Valley, about a dozen canals, thirteen perhaps, with the combined capacity of about 2,000 cubic feet of flow per second. When the land is first irrigated, we estimate the duty of water here to be 60 acres per cubic foot, and requiring less water from year to year as it is irrigated until it reaches the minimum, when it will irrigate 150 or 160 acres. The canals now constructed would irrigate, in round figures, 200,000 acres.

The CHAIRMAN. Double the amount that is now under cultivation?

Mr. MURPHY. Yes, at the present time. But being irrigated a number of years, we think 50 per cent. can be added to that—another 100,000 acres—making ultimately reclaimed 300,000 acres where the canals are already completed in the Salt River Valley. There are now a half dozen completed canals in this county, in the Gila Valley, below the junction of the Salt and Gila Rivers, aggregating about 50 miles in length, and covering in round figures 50,000 acres. There are many projected canals in the Gila Valley; some partly built. The number of acres of land is variously estimated—probably aggregating, a low estimate, 200,000 acres—that is expected to be reclaimed in this county. The Gila River runs about 90 miles through this county before its junction with Salt River. I present for your observation a diagram showing the quantity of water in Salt River during the past twelve months. The lateral lines represent the number of cubic feet flow per second, and each of the vertical lines one day in each month. You can see at a glance the variable character of the water supply in this river. During four months it is only about 400 cubic feet per second, and in the last months of June and July not much above that, although perhaps 100 inches more. The yellow belt on the chart shows the season of growing grain, about six or six and a half months, beginning with the middle of November and ending with the middle of May. The quantity of water is always abundant during that season of the year. The canals now taking water out of the Salt River in this valley and aggregating 2,000 feet per second are represented by the lower red line, and it will be seen from this chart that during six months of the year there is not water enough to fill the canals; it will probably average about half enough. During the six and a half months included in the period from November to May there is more than water enough to fill the canals. In the month of March the main flow of water is 40,000 cubic feet, twenty times more than all the canals can carry. Therefore, if we had storage systems so that this water could be stored, it would irrigate at least 400,000 acres more of land. That is a low estimate. The main flow during those six and a half months is something over 8,000 cubic feet, nearly four times the amount of water that the present canals can carry. So that 800,000 acres of land could be added to the present quantity of land upon which grain crops could be raised, if the water were not used in summer to irrigate fruits. But taking the assortment of crops that would be grown here, such as alfalfa and grain, and the 300,000 acres which the present canals will reclaim, there could be added at least 400,000 more.

The land here is very fertile, with a grade of from 8 to 12 feet to the mile. It is very well adapted to the application of water, and requires practically no leveling for the purposes of irrigation. This map, you will see, is self-explanatory, and we file it with your committee.

The CHAIRMAN. Are you sufficiently well acquainted with the agri-

culture of the Territory to state the amont of wheat per acre that can be raised on irrigated land?

Mr. MURPHY. Our crops vary here as is the case in new countries. There is too much attempted. Some of our people who are beginners do not understand the proper methods of irrigating, and to some extent they damage their crops by excess of irrigation. So that, probably, their average land will not yield to exceed 1,500 pounds to the acre. I think it possible to produce here 2,500 pounds to the acre. We have had crops of 3,000 pounds to the acre.

The CHAIRMAN. What other cereals do you raise?

Mr. MURPHY. Barley, principally.

The CHAIRMAN. How much barley can you raise to the acre?

Mr. MURPHY. Certainly 3,000 pounds.

The CHAIRMAN. How much wheat and barley would be produced on the same land without irrigation?

Mr. MURPHY. None.

The CHAIRMAN. How much alfalfa can be produced to the acre where you have irrigation?

Mr. MURPHY. Certainly 8 tons.

The CHAIRMAN. Has the fruit production been of such a character here as to enable you to state how many oranges you can produce to the acre?

Mr. MURPHY. We have a few orange trees in bearing here; but I do not think we have sufficient data upon it to come to a conclusion.

The CHAIRMAN. And it would be the same as to lemons and limes? How is it with regard to grapes?

Mr. MURPHY. They grow luxuriantly, and we have a large crop.

The CHAIRMAN. What kind of grapes?

Mr. MURPHY. Raisin grapes, wine grapes, and table grapes. I am not familiar with the names; but they are such as are grown in southern California.

Mr. HINTON. Do the fruits ripen earlier here than in southern California?

Mr. MURPHY. Yes, about a month earlier than in southern California

STATEMENT OF WILLIAM M. BRECKENBRIDGE, OF PHŒNIX.

The CHAIRMAN. Did you make the survey that is shown by that diagram [indicating]?

Mr. BRECKENBRIDGE. Yes, I made a portion of it?

The CHAIRMAN. Where can water be stored and how?

Mr. BRECKENBRIDGE. There are several points; but the best point that I settled on was at the mouth of Tonto Creek, a little above the mouth of Mazatzan Cañon. The best point was 2,900 feet above this point [indicating the mouth of Tonto Creek and east thereof].

The CHAIRMAN. Describe that point.

Mr. BRECKENBRIDGE. I made a map of that. In this [indicating] is the dam site. This [indicating] is the proposed water storage of the Upper Salt River.

The CHAIRMAN. Explain that map; or does it explain itself?

Mr. BRECKENBRIDGE. Mazatzal range cuts through Salt River, and this [indicating] is a big cañon with mountains on each side, 1,500 feet high. The slope is one to one.

The CHAIRMAN. It is perpendicular, then, for 100 feet?

Mr. BRECKENBRIDGE. Yes; that throws the water back eastward

16 miles on the Salt River, where it boxes again in the Sierra Ancha. For the first 2 miles from the mouth of Tonto Creek, point of construction already suggested, the average width is 2,640 feet, and the average depth would be 180 feet, calling the proposed dam 280 feet high. The next 2½ miles opens out into a valley, the average width being 2 miles, and depth 140 feet. The river then narrows up at Steamboat Rock, 4½ miles above, so that it is only a quarter of a mile wide, with an average anticipated depth of 130 feet. Then above the Steamboat Rock passage for the next 10½ miles the average width is 2 miles, and the average depth, as marked here, will be 70 feet [indicating on the map]. I took them by sections, in short sections, and I tested them several times at different times in the day. Then, also, Tonto Creek, with a width of 1¼ miles, could be made to obtain an average depth of 80 feet. There is ample space at a box cañon coming in from the south, where a waste-weir could be built, so that the river, when it arrived at a certain height, might run over that and not into the dam. That, I think, is about all. The contour lines outside of the water are indicated on my map.

The CHAIRMAN. Have you estimated the number of cubic feet per second that the proposed reservoir will contain?

Mr. BRECKENBRIDGE. Yes; I have estimated the amount it would hold in cubic feet. The report will be filed with you. It is a little over a billion cubic feet.

The CHAIRMAN. Enough to irrigate an immense body of land?

Mr. BRECKENBRIDGE. Yes; I have the figures. They are in the report which will be handed to you.

EXHIBIT B.

RESOURCES OF MARICOPA COUNTY.

The people of Maricopa County, Ariz., through the Phœnix Chamber of Commerce, by its chairman, H. E. Kemp, submits the following for the consideration of the committee:

The county contains 5,986,560 acres of land, 3,000,000 of which, including that covered by canals, can, by a judicious system of impounding the drainage and storm-flood waters, be reclaimed to cultivation and settlement. The report of William M. Breakenridge, county surveyor, to our board of supervisors, which is herewith submitted, shows that by building a dam in the Salt River, in the northeastern part of the county, enough water can be stored to reclaim all the desert mesa land lying north of the Gila River between Phœnix and the Colorado River at Yuma. Sufficient quantities of water annually flow through the Salt River to fill this reservoir several times. It is our belief also that, by the selection of suitable reservoir sites along the Gila, water enough can be stored to reclaim all the lands south thereof in this county. The Agua Fria, where it enters the Salt River Valley, in the dryest season carries a stream of several thousand inches of water. If properly utilized there is sufficient in this river to irrigate all the land, some 75,000 acres, lying between it and Cave Creek, and by a reservoir the land could be made available. In Maricopa County alone more has been done in reclaiming desert land than in any other portion of the Territory.

In the Salt River Valley the following canals have been taken from that river:

	Length.		Length.
Arizona	41	Utah	6
Grand	22	Farmers	5
Maricopa	14	Highland	22
Salt River Valley	18	Dutch Ditch	4
San Francisco	9	Monterey	4
Tempe	19	Griffin	3
Mesa	9		

These water-ways cover in the aggregate 250,000 acres of land, of which 187,500 have been reclaimed, and 125,000 acres are annually cultivated.

On the Gila are the following canals which have been completed:

	Length.	Acres.
Buckeye	30	20,000
Gila River	8	5 000
Enterprise	12	6,000
Gould & Bros	8	3,000
Palmer	22	12,000
Citrus	14	5,000

Besides these are the following canals now in process of construction: The Monarch Ditch, 8 miles long, which will cover 2,000 acres; the Gila River Irrigation Company, which takes the water at Black Butte, below the mouth of the Hassayampa River. This company has 12 miles of their canal completed. They propose to put in a dam 1,755 feet long and 75 feet high, and carry the water south and southwest, taking in the entire valley on the south and east sides of the river to the line of Yuma County, making a canal 75 miles long and covering 500,000 acres. The Gila Bend Canal Company starts from Gila Bend on the south side of the river. They have completed 22½ miles of the canal, which is to have a total length of 30 miles and cover 18,000 acres. Under this canal about 3,400 acres has been cultivated this season. The same company are building a large canal, taking the water about 2 miles above and running southwesterly a distance of 50 miles, intending to reclaim 80,000 acres, much of which has been filed upon.

Evaporation is very great in the valleys. During the summer months it will average about four-tenths of an inch every twenty-four hours; so that reservoirs should, wherever possible, be constructed in the higher altitudes. It is the general policy of our people to flood their land in winter, when water is abundant, which, by creating a reservoir of absorption, making frequent and heavy irrigations unnecessary during the months of June and July, when water is scarce. Since the first settlement of the valley of the Salt River the water has risen 30 feet nearer the surface. In some places fruits and alfalfa are now grown without irrigation. Another fact is noticeable; the water used in irrigation, except that lost by evaporation, percolates through the soil and finds its way back to the river. More water flows into the Gila from the Salt River in the dry season, covered by the months of May, June, and July, than before the first canal was built in the valley. Forty miner's inches of water is calculated to make a cubit-foot flow per second. One miner's inch is sufficient to cultivate 3 acres in grain or alfalfa, and 5 acres in fruits or vineyard.

The principal grain crops of our county are wheat and barley. The past season there has been produced about 40,000,000 pounds of barley and about 30,000,000 pounds of wheat. The yield of wheat is from 1,200 to 1,800 pounds per acre, and of barley from 1,800 to 3,000 pounds per acre. Sorghum and sugar cane are grown to a considerable extent for the sugar they contain and for feed. Corn is confined to a few hundred acres each year. Oats are native, and are cut in quantities every year for hay. Timothy, Bermuda, and blue grass do well, but alfalfa is the principal grass grown. Once rooted, it requires no attention except to irrigate it three or four times a year; grazed, an acre will support two and a half head of horses for one year, and from ten to twelve head of sheep or hogs. It can be cut from four to five times annually, and yields from 6 to 8 tons to the acre. The hay is very nutritious, and as a pasture for all kinds of stock can not be surpassed.

The mesquite and cottonwood are native trees, but the ash, cork elm, pepper tree, catalpa, willow, umbrella, lombardy poplar, North Carolina poplar, mulberry, palm, magnolia, locust, and tamarack have been introduced with marked success.

The cottonwood and North Carolina poplar grows from 18 to 20 feet in a season, fruit trees from 12 to 15, grape vines from 25 to 40 feet.

Up to five years ago very little fruit of any kind was grown in the county. Since then the planting of orchards and vineyards has increased every year, and no better section exists for the growing of nearly all citrus and deciduous fruits. In the lower Gila Valley lemons, oranges, figs, grapes, and pomegranates can be grown in great perfection. In other portions of the valley and through the valley of the Salt River peaches, pears, apricots, pomegranates, figs, French prunes, apples, oranges, almonds, quinces, dates, blackberries, and strawberries, and every variety of grapes grow in perfection.

There are now planted through the Salt River Valley 8,000 acres in vineyard and 3,000 in orchard trees. Of oranges, 200 acres are in cultivation. From experiments made the growing of this fruit will be a success. Olives have been planted in an experimental way. It is too soon to speak confidently as to the results, but as they have been successfully cultivated near Florence, in Pinal County, there seems to be no reason to doubt that good results will attend their culture in this county. Apricots, peaches, and kindred fruits bear heavily, yielding from 300 to 500 pounds per

tree. Vineyards in full bearing give from 6 to 8 tons to the acre. Raisins have not yet become an export commodity with us. The Alexandria muscat, grown in this valley, contains a greater quantity of saccharine matter than elsewhere, and from experiments made in raisin-making we are justified in the statement that 3 pounds of this grape will make 1 pound of raisins, which is a more favorable proportion than in any part of this habitable globe. Another advantage which our county has in the prosecution of this industry over the raisin districts of Spain or California is that the drying and curing can be done in the open air without damage from rain or dew. Some experiments have been made in the manufacture of sherry wine with satisfactory results. All our wines have a strong sherry flavor, and expert viticulturists who have examined into the matter claim this to be the only port and sherry district in America.

The growing of early and late vegetables will also become a source of great profit. This is a country that produces fresh fruits and vegetables every month in the year. Where grown in the open air peaches, figs, tomatoes, and cantaloups can be gathered in December, and where the soil is a rich alluvial, varying in depth from 10 to 12 feet, and inexhaustible in its durable fertility.

The Indians occupying a reservation in this county have cultivated their land for two hundred years without apparent injury to the soil and without change of seed. After their crude method of farming they raise better crops of grain than are harvested in any of the wheat-growing districts in the Mississippi Valley.

That this portion of Arizona was once the home of a large population supported by agriculture is unquestioned. Near Gila Bend are found the traces of their old canals. All through the eastern portion of the Salt River Valley are the mounds covering their ancient dwellings and the lines of the canals that spread the life-giving waters over the arid soil. Frank H. Cushing, under the direction of the Smithsonian Institution, has spent sometime in exploring the old ruins of this county, and gives it as his opinion that at one time it contained a population of more than half a million.

We have in a brief way adverted to what has been done in the reclamation of desert land and the value of such land when reclaimed, in order to show you the importance of well-directed efforts to utilize every gallon of water that now flows to the sea. These lands, made productive through irrigation, will, in a high state of cultivation, support in easy independence three hundred souls to the square mile.

In Maricopa county we have of this quality of land 3,000,000 of acres that, if a liberal policy is pursued on the part of Congress, will be reclaimed and placed under cultivation in the next ten years; and on these lands, within the lives of young men now living, will be supported a population of one million and a half of souls. Within three years the arable area of the county has been doubled; the population and property values have increased in like ratio. Maricopa county has a population of 15,000 and property values amounting to $15,000,000, and is rapidly growing. If the laws respecting desert land entries are not repealed we are certain that every year will add to the quantity of land reclaimed in this county, but if entries are confined to homesteaders, then we are equally certain that such a policy would work most serious injury to our material progress, unless Congress should lend the nation's credit to the construction of the necessary canals and reservoirs. In our judgment any restriction would delay indefinitely the settlement of arid lands. Had they been open to settlement only under homestead law, it is fair to say that lands would have been reclaimed only where the ditches could be taken out at small cost, and that the lands under the Arizona, Highland, Buckeye and other canals in this county would have been desert to-day, for the capital necessary for their construction would not have been forthcoming had those advancing it been deprived of all advantages to be derived from filing upon lands their money was to reclaim.

The interests of the county, Territory, and nation at large are identical in this matter, and that is, to have these lands made productive and as soon as possible made to share their portion of the burdens of taxation and contribute their quota to the products of the country. While we would rejoice to see a family on every 40 acres, yet if it is going to take a hundred years to accomplish this result, as seems probable if restrictive legislation is persisted in, we submit that better results would follow could they be reclaimed in ten years, even if every settler owned a full section. The cost of conducting water upon land in this Territory is from $8 to $12 per acre. If the land owner is not to be peoned to the ditch owner, he should have an interest in the canal, otherwise he is always at the mercy of the corporation controlling the water. To expect community enterprise to construct waterways, costing from one hundred thousand to several millions of dollars, for the purpose of allowing each individual to enter a homestead, is chimerical and visionary. If done at all, it must be by capitalists, and capital entering a new country always asks large returns upon its investment. We invite your attention to this subject, and respectfully submit that the people of America will be best served by leaving the laws relative to desert entries as they were before the passage of the act creating the United States Irrigation survey.

GENTLEMEN: I beg leave to submit the following report in regard to water storage in Maricopa county. After a careful examination of the river I find that about 400 yards below the junction of Tonto Creek with Salt River, the river runs through a box cañon, the sides of which are nearly vertical for about 100 feet, and then slope back at about 1 to 1. It is about 201 feet wide at the river edge and the bed rock is very near the surface. At this point a dam could be erected, 200 feet high, that would back the water up Salt River to where the river cuts through the Sierra Aucha Mountains, a distance of 16 miles. The valley is wide, and as it is irregular, I herewith give you the dimensions in sections, commencing at the dam site and measuring up the river for a distance of 16 miles:

	Average width	Average depth.
		Feet.
First 2 miles	2,640 feet	180
Then 2½ miles	2 miles	140
Then 1 mile	1,320 feet	130
Then 10½ miles	2 miles	70
Besides, the water would block up Tonto Creek for a distance of 10 miles	1½ miles	80

Total on both streams in cubic feet, 93,689,128,000. Add to this 10 per cent. for the water that would back up Pinto Creek, Sallamay, and other streams and gulches, would give a total of 103,058,040,800 cubic feet; making the largest reservoir in the United States. Limestone and sandstone are in abundance, and about 600 feet below the proposed dam site a box canyon empties into the river from the south. The material that would have to be taken out of the side of the canal to build the dam would form a waste weir for the river into the said box canyon, so that no water from the river, after the reservoir was filled, need ever flow over the dam, thus obviating all wear by water on the dam.

There is plenty of timber on the Sierra Aucha Mountains for all building purposes 20 miles from the proposed site. A large limestone ledge crosses the river about 100 feet above the site, which would furnish all lime necessary, and there is plenty of timber in the vicinity for burning it. There are in the Salt River Valley, which would be covered by the proposed reservoir, 4,100 acres taken up by settlers, of which 678 acres are cultivated. On Tonto Creek there are 2,040 acres taken up, of which 224 acres are cultivated.

Total acres settled on	6,104
Total acres cultivated	902

The cost of building the proposed dam and reservoir would not exceed $1,500,000, and it would supply enough water to irrigate all the land in the valley from the Arizona canal dam to Yuma.

The present capacity of the canals in this valley is about 60,000 feet per second, covering a body of 240,000 acres of land, of which 160,000 are under cultivation. It would take over two years to empty the reservoir with the canals we have at present, running at their full capacity, and the water would irrigate all the cultivated land fifty times, allowing 3 inches of water in depth for each irrigation.

Very respectfully,

W. M. BREAKENRIDGE,
County Surveyor.

The BOARD OF SUPERVISORS OF MARICOPA COUNTY.

STATEMENT OF LINCOLN FOWLER, OF PHŒNIX.

Senator REAGAN. What is your occupation?

Mr. FOWLER. I have had the management of some of the canals as director and foreman. I am also a lawyer ond real estate dealer.

Senator REAGAN. You have heard the course of this examination. Will you proceed, in your own way, and state what are the prospects for irrigation in this country?

Mr. FOWLER. I have lived here thirteen years, and the gentlemen who have preceded me have stated fully about the present system of irrigation. But I think there might be stated that very considerable

bodies of land, perhaps to the extent of 200,000 acres, might be added to the available farming land of the county.

Senator REAGAN. Of this county?

Mr. FOWLER. Yes. In the western part of the county there is one point where a considerable underground river (perhaps as large as the Santa Cruz, which passes Tucson and has never been made available for irrigation), might be made to furnish water for quite a large tract of land. There have been no measurements made there for reservoir sites, but I have been to a very good place where one exists for that purpose. In the southern part of Pima County the Papago Indians have a system of irrigation from small streams that come down from the mountains, and in the flood-time they gather these waters together by damming and conducting them upon the land. In that way considerable tracts are irrigated by them.

Senator REAGAN. Are those the perennial streams, or just the rain-water?

Mr. FOWLER. Storm floods—storm water. Most of the year there is no water at all running in those places, except when a sudden fall of rain comes. That same system was used in this county by the ancient race which lived here. The people who occupied this country in ancient times have left behind them in many places traces of irrigation works. Those places are not now covered by canals. But the land seems to have been farmed in that way, and the farms of the ancients seem to have covered nearly as great an extent of country, supplemented by those provisions for storm water, as is cultivated here now. The remains of their buildings and canals seem to show that such was the case. It has been estimated that the valley at one time supported a population of from three to five hundred thousand persons.

The CHAIRMAN. Do you mean this valley?

Mr. FOWLER. Yes.

Senator REAGAN. State your authority for that estimate.

Mr. FOWLER. One authority is Lieut. Hamilton Cushing, of the Smithsonian Institution. We have a number of sites for reservoirs where no permanent streams exist; but I believe they might be made available to supply large tracts of good land. This ancient people of which I have spoken, and which are now extinct in this country, used not only the permanent streams but seem to have used the storm-water system of irrigation in vogue among the Papagoes, and perhaps supplemented it by small reservoirs; of which, however, except in a few places, there is no direct evidence.

Senator REAGAN. Are any of these ancient reservoirs in a condition to be seen? Are they still in a condition of preservation so that they will convey water?

Mr. FOWLER. I am told that there is evidence of one in the neighborhood of Florence, but as to the extent of its remains I have no personal knowledge.

The CHAIRMAN. Have you information as to the manner of their construction and the material out of which they were constructed?

Mr. FOWLER. Earth principally. There is one point in connection with the irrigation of this country that is very material. If we can add, as has been stated here, 400,000 acres to the cultivated land of this valley, it is likely that the added flow of the river, which will return to the river after this land has been cultivated, will make it possible to add 50 per cent. to that area at lower points on the river.

The CHAIRMAN. More than you could do now?

Mr. FOWLER. Yes. It has been shown in the valley that during the

last few years there is rising opposite Pima, La Tempe, and down the river for a distance of 10 or 12 miles from 5,000 to 10,000 inches of water. That is re-appearing in the neighborhood where eight or ten years ago in dry times the river might be dry when the ditches were full. That water rises from underground sources, and I take it that 400,000 acres added at this point will probably add 200,000 acres at points below, between the lower end of this stream and Yuma on the Gila River.

The CHAIRMAN. Mr. Fowler, you are a lawyer and have given considerable attention to the land laws, and such modifications as seem to you necessary for the proper reclamation and utilization of our public lands within the arid areas of the United States, will you give the committee the result of your study and observations?

Mr. FOWLER: I am gratified at the opportunity, and take this occasion to offer as part of my statement a bill I have prepared suggesting a mode of distributing the arid portion of our public domain. I will read it:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That there is hereby granted unto the several States of California, Colorado, Nevada, and Oregon, and to commissions to be appointed by the President, by and with the advice and consent of the Senate, as hereinafter provided, for the use and benefit of each of the Territories, respectively, of Arizona, Washingington, Idaho, Montano, New Mexico, Utah, and Dakota, the whole of the desert lands in each of the said States and Territories remaining unsold by the United States on the first day of January, anno Domini eighteen hundred and ninety, to enable the said States and Territories to construct the necessary canals, reservoirs, water-ways, and artesian wells for the reclamation of the desert lands embraced therein.

SEC. 2. That it shall be the duty of the Secretary of the Interior to make accurate lists and plats of all such lands, and transmit the same to the governor of each of the said States, and to the commissioners of each of the said Territories, after their appointment by the President, in which such lands may lie, and at the request of the governor of any of the said States, or the commissioners of any of said Territories, to cause patents to be issued to said State, or commissioners of said Territories, for the use and purposes herein mentioned, conveying to said State or Territory the fee-simple of said land.

SEC. 3. That the proceeds of the sale of said lands, whether from sale or by direct appropriation in kind, shall be applied exclusively so far as necessary to the reclaiming of said lands by means of canals, reservoirs, water-ways, and artesian wells.

SEC. 4. That in making out lists and plats of land aforesaid, all legal subdivisions, the greater part of which is dry and of desert character, and which will not without irrigation produce some agricultural crop, shall be deemed desert land within the meaning of this act, and shall be included in the said lists and plats; but when the greater part of the subdivision is not of that character the whole of it shall be excluded therefrom. In segregating large bodies of land notoriously and obviously dry and of desert character, it shall not be necessary to subdivide the same, but to run the exterior of such body of land.

SEC. 5. That upon proof by the authorized agent of any State or the commissioners of any Territory herein named, before the Commissioner of the General Land Office, that any of the lands purchased by any person from the United States prior to the first of January, eighteen hundred and ninety, were "desert lands" within the true intent and meaning of the act entitled "An act to provide for the sale of the desert lands in certain States and Territories," approved March third, eighteen hundred and seventy-seven, the purchase-money shall be paid over to the State or commissioner for the Territory wherein said land is situate; and when the lands have been located by warrant or scrip, the State or commissioner for the Territory shall be authorized to locate a like quantity of any of the public lands subject to entry, at one dollar and twenty-five cents an acre or less, and patents shall issue therefor. The decision of the Commissioner of the General Land Office shall be approved first by the Secretary of the Interior.

SEC. 6. That said commissions shall consist of five members each, three of whom shall be appointed by the President in the manner specified in section one of this act, who shall be citizens of the Territory in which such commissions shall act, and who shall hold their office for a term of four years and be subject to the "tenure of office" *act of* April fifth, eighteen hundred and sixty-nine. The salary of each of said commissioners shall be two thousand five hundred dollars per annum, payable quarterly,

upon warrants drawn by the Secretary of the Interior, from the fund created by this act, known as the land reclamation fund. The Territorial governor and the surveyor-general shall, by virtue of their offices, be members of said commission, but shall receive no salary as members of said commission. The Territorial governor, by virtue of his office, shall be ex-officio president of said commission.

SEC. 7. That it shall be the duty of said commissions to receive from the Secretary of the Interior patents conveying the fee-simple of the desert lands in their respective Territories from the United States, and hold the same in trust for the benefit of said respective Territories, and issue like patents of the same to purchasers of scrip who shall have complied with the rules and regulations which the Secretary of the Interior shall prescribe as to the selection and location of said lands so purchased with said scrip. They shall prepare and transmit to the Secretary of the Interior lists of the lands located prior to January first, eighteen hundred and ninety, as provided in section five of this act. They shall establish districts of lands within their respective Territories lying contiguous to or being susceptible of irrigation by different watersheds situate therein, and shall apply the money arising from the sale of lands in each district to the aid of improvements in the canals, reservoirs, water-ways, and artesian wells situate within said district. They shall cause to be made a complete topographical and hydrographical survey of the Territories, and for that purpose shall devote so much of the general fund as may be necessary for that purpose. They shall deposit all moneys received with the Territorial treasurer of their respective Territories, taking his receipt therefor, and shall be allowed to draw from it upon warrants signed by the governor, as ex-officio president of the commission, and attested by their secretary, for the use and purposes herein specified. They shall sell at public auction, to the highest bidders, for lawful money of the United States, land scrip, after advertisement in three newspapers of general circulation within the Territory for thirty days prior thereto, at not less than one dollar and twenty-five cents per acre, the proceeds of such sales to be deposited with the Territorial treasurer, and to be known as the land reclamation fund. They shall make annual reports of the business transacted to the Secretary of the Interior, and shall at all times be subject to the rules and regulations and forms prescribed by said Secretary. When any of said Territories shall be admitted as a State, then the commission for said Territory shall render a final account of all business done by them, and shall surrender all books, records, and papers to the governor thereof, who shall review the same, and, if by him approved, said commission shall be by him dissolved.

SEC. 8. All land lying within an irrigation district shall have a vested and indefeasible right of use of water for irrigation, under the control of the boards of district and Territorial commissioners.

School lands already granted shall not be affected in manner of grant or sale by the provisions of this act, but shall have the same right to use of water for irrigation as other land in the same district, when sold, on pro rata payments.

This act shall not affect appropriations of water already made, but all appropriators shall be required to appear, upon due notice, before the Territorial commissioners and prove their respective rights, which, after determination by the commission, shall thereafter form the base of their title.

SEC. 9. All sales of land scrip under this act shall be to citizens of the United States and no others, and not more than eighty acres shall be sold to one person. The scrip may be located on any land of the district for which it is sold, and can not be used elsewhere. The commissioners shall not sell more scrip for a given district than the amount of land situate therein. The land scrip shall be issued to the purchaser, whose identity must have been verified before a court of record or United States land office, but the purchaser may be represented by an authorized agent to receive and locate the scrip, and for the purpose of voting at all elections provided for herein for the space of two years after location of scrip and no longer. Every purchaser shall locate his scrip within thirty days by filing at the land office of his district upon a definite tract, not exceeding the acres designated in the scrip.

The scrip shall be absolutely void if not located within thirty days and money forfeit to the fund to which it is paid. The scrip, or title under it, shall not be transferable, nor shall it be liable for any lien or debt for the period of three years after location. The purchaser shall be required to take up actual residence on the land within two years after the location of scrip and live continuously thereon for the space of one year, when the Territorial commission herein named shall, upon final proof being made by the settler, issue a patent to the settler.

SEC. 10. Within sixty days after the sale of scrip in a given district the commissioners of the Territory shall call an election, at which all those who have located scrip shall have the right to vote, for the purpose of electing a board of five commissioners, to serve the district for the term of two years, and a water-master, to serve for a like term. The Territorial commissioners shall call an election two months before the expiration of a term of a board of commissioners. The first board elected in a district shall hold office until the first day of January of the year following that

ends with an even number. An election shall be called by the Territorial commission upon written application of ten per centum of the scrip locators, for the purpose of issuance of bonds of the district, recommended by the district board and approved by the Territorial board, and if at such election seventy per centum of all the votes cast shall be for the issue, it shall carry. The general laws of the Territory shall govern when an election shall be held, except as provided and regulated herein.

SEC. 11. All bonds issued by and under the provisions of this act shall be paid, principal and interest, by the levy of a tax annually upon the value of the land of the district for which the bonds have been issued. This tax shall be levied and paid after the same manner and by the same officers as those who collect other county taxes. The total amount of money necessary to be raised for each year shall be estimated by the Territorial commission, and said estimate furnished to each county board of equalization, upon which they shall base the levy for this purpose. All money collected for this purpose shall be paid in to the Territorial treasurer for the benefit of the district levied upon.

SEC. 12. The district commissioners shall give bonds in sum fixed by territorial commission, and may be removed for cause.

They may expend the money derived from sale of scrip and all other sources for the construction of such system of water-works for irrigation for their district as are first approved by the Territorial commission.

They shall distribute and regulate the water used for irrigation in their district justly and equitably through the water master, who shall be their executive officer.

Salaries of the officers of districts shall be fixed by the Territorial commission.

SEC. 13. The annual expense of maintenance shall be met by such just and equitable scale of rates per acre for the use of water as the district commission may fix, subject to approval by Territorial commission.

SEC. 14. Any bonds issued under provisions of this act shall never become a charge against the United States, any Territory or county.

Before the issuance of any district bonds the Secretary of the Interior shall cause the proceedings under which it is proposed to issue them to be reviewed, and, if found regular and according to law, shall cause the bonds to be approved, when the bonds shall be returned for issuance.

SEC. 15. That the Secretary of the Interior shall provide such forms, rules, and regulations as shall best subserve the purposes and provisions of this act.

SEC. 16. That this act shall take effect and be in force on the first day of January, anno Domini eighteen hundred and ——; and all acts and parts of acts in conflict therewith are hereby repealed.

The CHAIRMAN. Yours is one of the methods suggested. Objections are made to the plan, with which, Mr. Fowler, you are quite familiar. What have you to say as to these, and will you explain briefly how this measure, in your judgment, would work?

Mr. FOWLER. I think the objections are generally aimed at points of details. I shall not make an argument here as to whether or no the control of any portion of our public domain while in process of settlement should pass in whole or part to the several States and Territories wherein they are located. That is a question to be considered more appropriately in the wider forum of Congress. I offer my plan simply as a suggestion towards the important discussion on the reclamation of our arid lands, which your committee's beneficial labors, as well as the pressure of public development are sure to bring about. I pass, therefore, with the committee's leave, to a consideration of such objections to my proposition as I have heard made.

The first point is that such "segregated control and disposition" would be objectionable. This may be answered by a general statement that the varying conditions of the States and Territories would make it necessary to have a varied system from north to south, or from grain growing to fruit growing: that the people of a certain State or Territory named would probably be better qualified to handle its conditions than those of other or different localities. Should that, taken with the conditions specified in the latter part of section 1, be thought insufficient to compel the States that are to receive the land to do their duty in the premises, then in place of a direct grant of lands to the States

there might be substituted control by commissioners, such as my bill contemplates.

This would furnish some definite pact between the General Government and that of each State as to such land disposition, by keeping the control directly under the Interior Department. It has been objected that the land subdivisions provided by this bill of mine are not small enough for the conditions of semi-tropical sections and districts like southern California or southern Arizona. It is also suggested that my bill is not sufficiently stringent in guarding against the opportunity offered under our present land laws for making quasi-fraudulent entries, ending in the transfer to speculative parties of large bodies of public lands which Congress has designed should be occupied as homesteads. All these are matters of legal details to be considered and provided for if shown to be reasonable.

In section 5 of my bill it is proposed that the Territorial commission or the State shall have the benefit of the value of all desert land already sold, also in line scrip. This is intended to furnish funds to commence or continue works of survey and hydrography, and to set the plan in operation. All water-district settlements in Territories would be practically incorporated for these purposes, as are California districts under the "Wright law," except that their source of life would be from Congress and through the Interior Department in place of the State.

This will be seen by section 7, which provides for the general powers of the commission. It is modeled largely from the "Wright law" of California, varied, of course, to suit the different conditions of working under the Interior Department. Appropriators under the bill would be required to prove their claims and appropriations. In many cases equities have already accrued from use and under intent of compliance with the desert-land law. In more cases those who hold them would no doubt be glad to turn over their interests at cost to a water district.

The general provision of usufruct of water is necessary to lay a ghost that has troubled California for many years in the shape of "riparian rights." School lands are untouched by this bill, except that they too should have right of irrigation upon pro rata payments. The rights of present appropriators form a very vexatious base for much litigation, and this act would effectually and at once bring it to a speedy close.

As section 9 of my bill is intended to especially promote the colonization of arid lands, many people of moderate means would by association or colonies send their agents to choose eligible sites for future settlements, and would be eager bidders for lands that would be occupied as soon as water could be brought upon them. Under the homestead law that is quite impracticable. This I believe to be one of the strongest and best features of the bill I suggest. I base my opinion on experience of over fifteen years in arid districts.

That the scrip I propose must be located within thirty days will keep the business of the district well in hand. That the scrip can not be used out of the district for which sold will prevent any chance of its having a speculative character. That the scrip locater may be represented for two years by agents will give colonies a chance for successful location at bottom advantages.

Section 10 is intended to convey, for the purposes of this bill, about the same general line of powers ordinarily vested in school districts or municipal corporations, except that so much of detail is unnecessary, for the reason that general laws would provide for nearly everything wanted, while for this especial line of duties it seems that, taken with

the general instruction of the Interior Department and Territorial commission, it would be ample. But, of course, it can readily be maed more rigid and detailed.

The bonds to be issued in pursuance of this plan will be for the primary purpose of improving and giving value to the land of a district; hence the land should be held responsible for their payment and improvements. Personal property, etc., should go free, so far as possible, from this tax. This would tend to promote small holdings, high cultivation, and induce a successful colony system.

Should this plan be modified in the case of the States to be benefited by having a State commission in place of a direct grant, then the States accepting would need to provide machinery for the levy of taxes in accordance with the grant; for, I take it, in matters of taxation Congress would not be authorized to go further than propose a grant on certain conditions. The several States would, if accepting the same, provide the method for tax levy and all details connected therewith. According to generally accepted theory, Congress may make such laws for Territories as they see fit for any purpose. The approval of the Territorial commission is inserted by me to provide uniformity of construction and to prevent any ill-advised steps being taken. The commissions are to be clothed with the power of distribution of water, with a water master as executive officer in each of the district boards. As the district boards will know much better about the annual cost of maintenance, they will name the rate per acre, with the same reserved power in the Territorial board. This provision is designed to definitely fix the validity and regularity of the issue, which under the California "Wright law" is provided for by the officers of the water district bringing the whole matter before a court of competent jurisdiction for judgment.

The Secretary of the Interior is to provide all the regulations and forms necessary to secure uniform and successful working of this act after the manner of other land laws. In summing up, then, I desire to say that under this proposed act the Government is protected from speculation either in water or land; first, by the water-works being owned by the community, and the land owned in small tracts being by right of purchase held not subject to debt as in the present homestead law, and the requirement that before title can be issued to the settler he or she must have resided on the tract at least one year. This term of residence being the last one of the three years is to render it possible for the settler to do so without evasion, for on the arid land of the west, which, as required by the desert-land law, must be of a character that will not produce an agricultural crop without irrigation, how can any settler support himself in advance of water to farm with?

It will be admitted by every one in the great majority of cases that two years after the commencement of work would be a short time to complete and put into operation an average system of irrigation and make the water available for the cultivation of the soil to sustain the homesteader. The era of land grants to corporations has passed, let us hope to never return, and callous would a public man be to the interest of his constituency who would invite its return; but what shall we term the gift of the water franchises of the arid region, that at the present can only be made available by the heavy investment of capital under terms that will make the intending settler subject to their exaction? Certainly protection and care is needed there.

It is not intended by this bill to interfere with rights already acquired, but to enable those who may need homes, even though now at a distance, *to get them* subject only to their own and governmental control. The cen-

tral purpose of homes for the people without a rent-gathering landlord is purely American; the further idea of water for irrigation at first cost, and under the direct control of the people using it, has come to be the main drift of the later laws of our States where irrigation is most used, and forms largely the basic idea running down through all laws on irrigation from Rome through the Spanish, French, and Mexican system of community ownership with the land and water in inseparable and undivided control.

It is hoped that this brief presentation of a matter of such vast importance will assist all those seeking to solve the question of disposal by our Government of the 700,000,000 acres of arid land to actual settlers, thus perpetuating and continuing the grand work of free homes for a free people.

I think, Mr. Chairman, I have covered all the explanations I desire to make in regard to my proposed bill. I should like to add my concurrence to the statements of other gentlemen as to the great importance to all our people of the pending national survey for irrigation purposes. Such a survey is absolutely essential, and whether the General Government keeps entire control, or whether, as I propose, some of its administrative powers over the public lands west of the Powell meridian be delegated to commissions in States and Territories, the survey for irrigation purposes should be completed, and as rapidly as possible.

COPY OF CIRCULAR SENT TO COUNTY OFFICERS.

The following was filed by the secretary of the Territory. The circular was framed and published as the result of a correspondence with the governor of the Territory and Engineer Hinton, the committee's expert:

(1) The location of all streams, rivers, and irrigating canals. These can best be shown on maps, sketches, or tracings, prepared on a scale of 2 inches to the mile.
(2) List of canals and ditches, giving as nearly complete as possible—
(*a*) Name of canal or ditch.
(*b*) Name of owners or officers and their post-office addresses.
(*c*) Date when built or first in use.
(*d*) Streams from which the water is diverted.
(*e*) Number of acres irrigated, and of cultivated lands.
(*f*) Number of acres of good land so located that they could be irrigated by an increase of the water supply in the canals or ditches now constructed.
(*g*) Number of acres that could be irrigated by new ditches or canals and new reservoirs.
(*h*) The available sites for reservoirs, either in the valleys or mountains, and the probable size of such reservoirs.

In addition to the above you are requested to reply to the following questions:
(1) What is the average depth of snow in your mountains during the winter?
(2) When does the irrigation season begin and end in each valley?
(3) What is the elevation of each valley above the sea?
(4) How much water, in miners' inches or in cubic feet, per second flows through each stream in your country at the point where it can be used for irrigation during the irrigating season?
(5) How much water could be stored in suitable reservoirs during the rest of the year?
(6) How much water is required in each valley or locality to irrigate an acre of sandy soil for each crop—small grain, grass, root crops, corn, orchard grass, etc.?
(7) How much water is required to irrigate an acre of clayey or alkaline soil in each valley or locality for each crop mentioned above?
(8) How often and how long at each time is the land irrigated?
(9) How many acres of crops have been lost this year from lack of water?

STATEMENT OF J. M'MILLAN, OF PHŒNIX.

Senator REAGAN. How long have you resided in Phœnix?

Mr. MCMILLAN. Three years.

Senator REAGAN. What is your occupation?

Mr. MCMILLAN. Superintendent of the Arizona Canal Company.

Senator REAGAN. You have been in charge of the canals—managing them?

Mr. MCMILLAN. Yes.

Senator REAGAN. Directing the distribution of the water?

Mr. MCMILLAN. Yes.

Senator REAGAN. Will you state the plan of distributing this water to the persons who use it, who furnishes the water, and what those who use it pay for it?

Mr. MCMILLAN. We distribute it to the water-users through lateral ditches which we have built on every section line. It is measured to them and delivered to them with their land through divide boxes. They pay for the use of the water $1.25 an acre each year.

Senator REAGAN. What company furnishes the water?

Mr. MCMILLAN. The Arizona Canal Company.

Senator REAGAN. Is water furnished on that charge during any portion of the year when it is needed?

Mr. MCMILLAN. During the entire year.

Senator REAGAN. And is there a limit to the amount that you furnish to the users?

Mr. MCMILLAN. They can have all they require as long as we have it.

Senator REAGAN. You have heard the course of this examination. The committee would be glad to hear any statement you desire to make which will give us information upon the subject of inquiry, so far as it bears on this section of country.

Mr. MCMILLAN. The land is so level in this section that irrigation itself is very easy as compared with other localities. We are not troubled with arroyos or washes of any description. The slope of the land is about 10 feet to the mile, running to the southwest, largely, and hence the main laterals run to the south and our dividing laterals to the west.

Senator REAGAN. Do the ditches that carry the water out of Salt River carry it over the southern plateau to the Gila?

Mr. MCMILLAN. Nearly so, but they do not reach the Gila. I desire to say that as to the service of water on these new lands, we use in the neighborhood of half an inch to the acre on fresh lands each year. As lands become older they need less water.

STATEMENT OF W. E. PLATT, OF ST. JOHNS, APACHE COUNTY.

Senator REAGAN. You represent the board of supervisors of that county?

Mr. PLATT. Yes.

Senator REAGAN. Have they made a report with regard to irrigation?

Mr. PLATT. Yes.

Senator REAGAN. You have a written report?

Mr. PLATT. Yes.

Senator REAGAN. By whom prepared?

Mr. PLATT. I prepared most of it myself.

Senator REAGAN. State generally what the report shows, and then file it.

Mr. PLATT. We are now attempting to irrigate about 12,000 acres of land, but we have scarcely water enough to water half that quantity so as to raise good crops. We have nearly 200,000 acres that we could water if we had a good reservoir. We have five or six reservoir sites already surveyed. They are shown in full in the report.

The CHAIRMAN. What streams of water pass through your county?

Mr. PLATT. The Little Colorado and its tributaries.

The CHAIRMAN. Then you are away up adjoining Utah?

Mr. PLATT. Yes, we are away up in the corner. We have an abundance of water when we do not need it. When we need it we have almost none. We have some five or six reservoirs in operation, which furnish all the water we have in the dry season. Our county grows almost everything except figs and oranges. We have every class of soil and can grow every class of vegetables.

The CHAIRMAN. Are you accessible to any railroad?

Mr. PLATT. Yes; the Atlantic and Pacific passes through about the middle of the county, 50 miles from St. John. We have 111 miles of railroad in the county. Our taxable property is $2,500,000. We have about 12,000 inhabitants.

The CHAIRMAN. Are those reservoir sites on public land?

Mr. PLATT. Partly. The railroad owns part of them.

The CHAIRMAN. Is there anything further you wish to say?

Mr. PLATT. I believe not. You will find everything in detail in the report.

The following is the report referred to by Mr. Platt:

REPORT OF APACHE COUNTY; ITS IRRIGATION CANALS, RESERVOIR SITES, ARID LANDS, ETC.

Apache County is situated in the northeast corner of the Territory, and embraces a country of about 100 by 120 miles, exclusive of the Indian reservations.

The county now contains a population of only 6,000 to 7,000 people, but with sufficient water to cultivate the land that is otherwise available, it would afford good homes for many thousands more.

The climate is excellent and well adapted to the raising of all kinds of small grain, vegetables, and all kinds of fruits that can be grown in a semi-tropical climate.

The county is drained by the Little Colorado River and its tributaries. The Little Colorado heads in the White Mountains, in the south end of the county, and runs in a northerly direction 50 miles to St. Johns, thence in a northwesterly direction to the Big Colorado River, in Yavapai County.

From the head of the Little Colorado to the first settlement, Springerville, it is about 15 miles; there being in that vicinity several good sites for storing water, and some 8,000 acres of choice agricultural lands, unoccupied, that could be brought under cultivation. Springerville is one of the best farming districts in the county, the land being very productive.

In addition to the Little Colorado, the following tributaries of that river run into the Springerville valley from the mountains, through which a great deal of water flows during the spring, but runs dry about the time irrigation commences: South Fork Creek, Water Cañon Creek, and Nutriaso Creek. On each of these streams there are good sites for reservoirs. There are two reservoirs constructed and owned by private parties in this valley, which are very successful in storing water for irrigation.

A committee sent from St. John's surveyed and made estimates on the following reservoir sites between Springerville and St. John's, a distance of 35 miles, and make following report:

Reservoir site No. 1.—This place is 25 miles above St. John's, 3 miles away from the river, and would cost $1,500; has a small living stream running into it from the mountains; drains 100 square miles of the White Mountain slope.

There may not be sufficient water to fill this reservoir every spring, but, from

reports of reliable persons, there would be ample water nearly every season. The embankment would be 300 feet long, 25 feet high, 70 feet thick at base, and 20 feet thick on the top. The reservoir, then, filled with water would cover 600 acres 12 feet deep. A natural ditch would convey the water from this reservoir 3 miles and empty into the Little Colorado, 22 miles above St. John's.

Reservoir site No. 2.—This site is 22 miles from St. John's, up the river, and 4 miles east from the Little Colorado, on "Coyote Wash." The work required would be masonry 495 feet long, 100 feet high, 100 feet base, and 20 feet on top; would cost about $50,000, and would cover 2,000 acres of land 50 feet deep on an average.

Rock and material for construction of dam is plentiful right on the ground. It is believed there is sufficient water passes down this stream every spring to fill this reservoir. At the same place by making only a wall 50 feet high the cost would be $12,000, and cover 1,000 acres 25 feet deep; no expense in conveying the water to the Little Colorado River from reservoir, and there are 1,500 acres of good land within 2 miles of the embankment that can not be irrigated from any other source. Eleven thousand acres of land could be better cultivated than at present from the above reservoirs, and 20,000 acres of good land within 10 miles of St. John's could use the surplus. Ten thousand dollars would make the necessary ditches to convey the water on the 20,000 acres near St. John's.

Reservoir No. 3.—The construction of a reservoir at this place, which is 16 miles above St. John's, would cost $5,000. An embankment 20 feet high, 60 feet wide at base, 20 feet on top, and 900 feet long would back the water over 700 acres at an average depth of 8 feet. The reservoir would be filled from the Little Colorado.

Reservation No. 4.—At the Salado Springs, 6 miles above St. John's, on the Little Colorado, is one of the finest places for storing water in the country. A wall and bank 70 feet high, with 100 feet base and 30 feet top, 600 feet long, would cost about $50,000; would back the water up the river for 10 miles, and would contain sufficient water to irrigate 60,000 acres of land during the irrigation season. About 1,000 acres of the land embraced in this reservoir site is claimed. There is always plenty of water passing down the river to insure the reservoir being filled. There are 25,000 acres of land between this place and 10 miles below St. John's, mostly vacant for want of water; and 8 miles farther down is a valley containing 13,000 acres of agricultural land not in use, and still farther down the river 17 miles another valley containing 60,000 acres of fair quality of land.

Reservoir No. 5.—This place is only 1 mile above St. John's, at a place known as the "Padre's Lake." An embankment 10 feet high and 1,000 feet long, costing only $2,500, would cover about 100 acres 6 feet deep. Said site is claimed by private parties, who hold it for speculation, as they have no land that could be irrigated from it, and the land embraced in this site is of no value for any other purpose, being a barren spot. A ditch necessary to fill it is now in use to convey water to the city lots of St. John's. There is abundance of water passes down the Little Colorado River during the thaw every spring to fill many such reservoirs, as described above.

Reservoir site No. 6.—This place is at the mouth of the Zuñi River, 20 miles below St. John's. The wall would be 700 feet long, 80 feet high, 120 feet wide on the bottom and 40 feet wide on the top, and would cost about $65,000. It would cover 7,000 acres 35 feet deep on an average. When full will hold sufficient water to irrigate 125,000 acres of land four times each season. The Zuñi River heads 100 miles east from said site, in the Zuñi Mountains. If this reservoir was made it would not be necessary to make all of the others mentioned above.

There is one reservoir about 2 miles above St. John's in successful operation, which has been in use three years. It is owned by the St. John's Irrigation Company. It covers about 50 acres 12 feet deep. Its original cost was about $4,000. It is the only source of water supply during the dry season for 3,000 acres of land near St. John's. It does not afford sufficient water for that much land, but would be ample for 1,500 acres.

With sufficient water for St. John's Valley, 20,000 acres of good agricultural lands could be brought under successful cultivation, most of said land being of a far better quality than is now in use.

The present population of St. John's is about 1,200.

There is a small reservoir in Concto, which has been in use for ten years and irrigates 250 acres. One thousand acres more could be used in that vicinity with an increase of water.

In the western part of the county, on the Show, Low and Silver Creeks, there are many good places for storing water, and considerable good land that would be brought under cultivation if there was an increase of water.

They have one small reservoir near Snowflake, on Silver Creek, that covers 50 acres with an average depth of 4½ feet.

There are several places that would be good sites for storing water on the Rio Puerco of the West and other streams that empty into the Little Colorado, with abundance of land available for successful cultivation when water is brought upon

it. There are also other locations or sites for reservoirs on the Zuni River and Little Colorado River that are not mentioned in the above report.

The amount of land under cultivation in this county at the present time is about 12,500 acres, over one-half of which is subject to drought and partial failure of crops every season.

The amount of land that could be successfully cultivated, and of good quality, is over 150,000 acres, and water sufficient to irrigate many times this amount of land passes down through the county every season.

Snow usually falls in the mountains from 8 to 12 feet each winter.

The irrigation season commences in some parts in February, and ends in October. In other parts irrigation commences in April and March and ends in September. The elevation of the county varies from 5,000 to 8,000 feet. Eighty-seven thousand one hundred and twenty cubic feet of water will irrigate one acre of sandy soil four times each season. One hundred and nine thousand nine hundred cubic feet will irrigate an acre of clayey soil four times in a season, which is the number of times necessary to irrigate for most crops.

STATEMENT OF WILLIAM A. HANCOCK, OF PHŒNIX.

The CHAIRMAN. What is your occupation?

Mr. HANCOCK. I am by profession a lawyer and civil engineer. I have lived in Arizona twenty-five years; was superintendent in charge of the construction of the canal intended for the irrigation of the Government farm at Fort McDowell in 1866, and was afterwards superintendent of the farm. I came to this valley in 1870 and have participated in the location and construction of nearly all the canals in the valley, and have been familiar with the whole valley for the past twenty years.

The CHAIRMAN. We shall be glad to hear what you can tell us about irrigation.

Mr. HANCOCK. We have now under the canals in the valley, from the junction of the Verde and Salt Rivers to Agua Fria, 235,000 acres of land susceptible of irrigation and cultivation. On the north side of the river the Arizona Canal with the older canals under it includes all the land practically susceptible of irrigation by the water from the Salt River. On the south side, if water is secured by storage, a new canal may be constructed above the Highland Canal that will cover something more than 50,000 acres to the east and south of the line of the Highland Canal and its possible extensions. This will make the area in this valley irrigable from Salt River approximate 300,000 acres.

If this entire amount of land was in cultivation it would require to properly irrigate it a flow of 150,000 miners' inches, or a stream equal to a discharge of 3,750 cubic feet per second. Such a stream would discharge in twelve months 116,640,000,000 cubic feet of water.

For the past twenty-five years the average natural flow of water in Salt River during the months of January, February, March, and April has been sufficient to afford the required water; so that, taking the average year, we should only need to secure by storage a supply of water sufficient for eight months, or 77,760,000,000 cubic feet. But during two years in the period named the natural flow of the river sufficient to afford the required water would not exceed three months in duration. To insure perfect success we must provide for the storage of sufficient water to supply the valley through the dryest year, or nine months, which would be 86,780,000,000 cubic feet. These estimates are made without any allowance for evaporation, seepage, or other wastage, and I think we do not need to make any. And, upon this point, suppose wastage from the causes named to be 33 per cent. of the water stored, that being the last-named quantity, 86,780,000,000 cubic feet,

one-third of it is 28,926,666,666 cubic feet. Now, to offset this we have the natural flow of the river during the nine months, and I will estimate this to be 50,000 miners' inches, or 1,250 cubic feet per second, and we have 29,160,000,000 cubic feet, or a little more than the wastage. These last are but approximate estimates, made without sufficient data to make them absolutely correct. I will say here, however, in support of the last proposition, that in September, 1868, the water in Salt River rose to the highest point ever attained in the twenty-five years that I have known it; and, further, that in twenty years out of the twenty-five years during which I have been here, some time in the summer, between the 1st of July and the 20th of September, the natural flow of water in Salt River has exceeded the required supply of 150,000 miners' inches, or 3,750 cubic feet per second, and such flow has continued from one to twenty days.

If the committee will refer to the chart furnished by the chamber of commerce they will comprehend what I mean when I say that if it had been made to illustrate the flow of Salt River for twenty-five years, instead of one year, it would have shown that the highest point reached by water was in September, instead of January, and that the average flow of the water during the months of July, August, and September produced by the summer rains would have been indicated by marks at least one-third the height of those for the months of December, January, February, and March.

Now, as to the reservoir site at the mouth of Tonto Creek. Contemplating the necessity for the storage of water for this valley twenty years ago, and when stationed for a time at Camp Reno in Tonto Basin, I examined the proposed site, and again with greater care nine years ago. I assured myself then that it would store sufficient water to successfully irrigate this valley.

The CHAIRMAN. I wish you would explain more fully the reservoir storage and dam site.

Mr. HANCOCK. I wish, for the benefit of the committee, the engineer in charge, and for the good of this valley and our people, to endeavor in a few words to show that, although hardly reconcilable in some respects, the statement made by Mr. Breakenridge proves that the Creator was not unmindful of the necessities of this valley when He placed upon Salt River above it the means of storing water for its irrigation.

I agree with Mr. Breakenridge in saying we may safely construct a dam 200 feet high, and that it will back the water up Salt River 15 miles and up the Tonto perhaps 8 miles; the basin is 4 and 5 miles wide in a part of its length, but is shallow except along the course of and near the beds of Salt River and Tonto Creek, but we may safely estimate that reservoir will equal a body of water 15 miles long by 2 miles wide and 100 feet deep. This is considerably less than the dimensions given by Mr. Breakenridge, and yet it will contain 83,635,200,000 cubic feet of water when full. This will be practically sufficient for the irrigation of the whole of this valley for nine months, even when we have 300,000 acres under cultivation, as the following estimates based upon the proposition that a constant flow of one-half inch miners' measurement, or 21.6 cubic inches per acre, will be required. Upon this basis the water required for one month is 9,720,000,000 cubic feet; for eight months 77,760,000,000 cubic feet, and we have for evaporation and other wastage the natural flow of the river during these eight months, and 5,875,200,000 cubic feet from the water stored in the reservoir.

Suppose the natural flow to be 750 cubic feet per second for these eight months, and we have 15,522,000,000 cubic feet, which added to the amount stored gives us 99,187,200,000 cubic feet, and from this subtract the amount required for irrigation, 77,760,000,000, and we have for evaporation and wastage 21,427,200,000, or practically 28 per cent. of the storage capacity, or equal to 1.4 inches per day for the mean surface of the reservoir during the eight months, supposing my estimate of its dimensions as I have given it above to be practically correct.

As to the probable cost of the reservoir: If the dam is built in the form of an arch up the stream, it will be, say, 250 feet long on the bottom with an average length, say, 425 feet, a width or thickness on the bottom of 130 feet, and 20 feet on top, and the average thickness is 75 feet, and this gives us 236,110 cubic yards, and at a cost of $4 per cubic yard it gives us $944,440. With all the material, except iron and possibly some timber, practically on the ground (for we find large bodies of limestone and gypsum in the near vicinity) this should be a liberal estimate, including the rubble which would be required to make it perfectly water-tight.

The cost of such a work and the means of raising the money to accomplish it are perhaps not within the province of the committee, but, nevertheless, as one of the Senators made some suggestion in regard to it, I will venture to discuss it.

The Senators will remember that a large portion of the land of this valley is already under canals, some of which were constructed more than twenty years ago, and those canals have from thence to the present time been used by the owners thereof in irrigating their lands. Large sums of money have been expended by the owners of these lands in the construction of their canals, and of some of them it is safe to say that unless their rights are encroached upon by subsequent appropriators, they have at all times, in the natural flow of the water in Salt River, an abundant supply of water. Perhaps 30,000 acres of the land in the valley is so supplied. From the owners of these lands we could not expect a contribution of $20 per acre for water rights under the reservoir. A much larger portion of the land is irrigated by means of subsequently constructed canals that do not afford an abundance of water at all times, but which, nevertheless, afford an ample supply to raise a crop of wheat or barley, or one or two crops of alfalfa, and in some years, when the rain fall is greatest, even more than that. If the Senators can realize this condition of things they will understand how difficult it will be to induce private capital to invest in such an enterprise.

The CHAIRMAN. We realize the difficulty fully. Have you any plan to suggest to meet it?

Mr. HANCOCK. There is a proposition which I believe is practicable, although it does not commend itself to the judgment of all our people. It is this: Let Congress modify the Harrison act to such an extent that the legislature of our Territory may authorize our county board of supervisors to issue bonds to the extent of $1,000,000; let the whole valley of the Salt be created an irrigating district, let a board of commissioners be appointed who shall have the control and management of the construction of the reservoir, and of the reservoir and the water it will contain after the work of construction is completed; let the bonds be issued and turned over to them as they will be required, and with the money derived from the sale of them they construct the reservoir. We suppose these bonds to be payable in thirty years with interest at the rate of 6 per cent. per annum. Some means must be arrived at to

make the sale of water rights and the use of the water pay the interest on these bonds and eventually pay the bonds; it must be made in some way from the land that is benefited by it. Is it not possible by some act of our legislature to make this a lien upon the 270,000 acres of land that will derive its permanent supply of water from the reservoir to the extent of $3.50 per acre? This would give us $945,000. The canal companies must receive the water from the commissioners, and not the individual farmers, and if the canals paid to the commissioners 50 cents per miners' inch per annum for the water, it would afford an income of $75,000 per annum, which would pay the interest on the bonds and the annual expenses.

If this proposition could not be made practicable, possibly some such scheme as several States adopted to construct levees on the Mississippi River could be made applicable.

The consummation of the proposition to store water for these lands will add $20,000,000 to the value of the land in the valley, and we can afford $1,000,000, or even $2,000,000, to accomplish it.

I will suggest another plan. Suppose we condemn all the existing water rights, and agree to pay for them, thus putting us all on an even footing, as though we never had secured any rights to the water. We can pay for the condemned rights with rights under the new and better system, and sell to the lands not properly supplied, and thus eventually pay for the cost of constructing the reservoir, and secure a fund to keep it in repair for a long period and pay all expenses for maintaining it.

The CHAIRMAN. All your suggestions are of value. Have you anything further to state?

Mr. HANCOCK. Yes. Where is outlying from this valley on the north, bordering on the Agua Fria River, and in one sense forming a part of this valley, from 75,000 to 100,000 acres of as fine land as any part of this valley; and here, again, on the Agua Fria, about 45 miles north of Phœnix, we have a natural place for a reservoir. At this point the course of the river passes between two perpendicular bluffs of solid rock. On the east side this perpendicular wall is 75 feet high, on the west it is but 30 feet high; from this height it inclines outward on an angle of 45 degrees for another 100 feet in height, when it again assumes the perpendicular to the height of 60 feet more.

The east side gradually slopes back for 900 feet or more until it rises to the height of 175 feet. A dam for a reservoir constructed here would be 300 feet at the bottom, and at the height of 175 feet it would be 15,000 feet long. This dam would back the water up the Agua Fria at least 10 miles and up Castle Creek from its junction with the Agua Fria, which is 4 miles above the site for a dam, probably 4 miles. At the junction of Castle Creek with the Agua Fria the reservoir would be approximately 100 feet deep. This reservoir would contain from twenty-five to thirty billion cubic feet of water when full. The Agua Fria and tributaries have the whole of the south and eastern slopes of the Bradshaw Mountains for a water-shed. One hundred thousand acres of land in this locality would require 24,000,000,000 cubic feet for six months, and as the summer rains on the Bradshaw range are sufficient to fill the reservoir as well as the winter rains, we shall have an abundant supply of water for the land. These lands are a portion of the public damain, and consequently no difficulty would be encountered in devising a plan for the construction of this reservoir with private capital. Probably $750,000 would be required to construct the dam and the canals to convey the water to the land.

The storage of water for this valley is the storage of water for the whole

of the Gila Valley to Yuma. Already the irrigation of the lands in this valley has increased the flow of water in the Gila below in the dry season. The strata of the gravel, sand, and soil here act as a sponge, absorbing the water that we use in irrigating, and, holding it for a time, gradually let it flow on to the river below, where it is taken out and used again for irrigating the lands below us.

When this vast body of water shall be stored and poured out upon this valley constantly through the dry season it will afford to the valley of the Gila a very much larger stream of water than they now get from our partial irrigation of this valley.

In some way all the lands to be benefited by this water storage should be called upon to share in the expense. I can not yet see just how it can be done. Some legislation must be had to enable us to do it. With my twenty-five years' experience here I should be able to devise some proper practicable plan, or at least to make some practicable suggestions. From what I have learned of the plan adopted for constructing the levees on the Mississippi, it would be good here. If some plan could be devised by which Government aid could be had without delay, it would be better.

Adjourned.

ON TRAIN FROM PHŒNIX, ARIZ.,
September 5, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF W. E. GUILD, OF FLORENCE, PINAL COUNTY.

The CHAIRMAN. You may state the condition of things in your county with regard to irrigation.

Mr. GUILD. Pinal County has an area of over 900,000 acres of land that are subject to irrigation. With a proper storage reservoir at Butte Cañon, on the Gila River 15 miles above Florence, this land could all be brought under cultivation.

The CHAIRMAN. Describe your reservoir sites and how the water supply is.

Mr. GUILD. This reservoir site at Butte Cañon in its narrowest place is 140 feet wide.

The CHAIRMAN. Has it been surveyed?

Mr. GUILD. Yes.

The CHAIRMAN. Have you the survey?

Mr. GUILD. Yes; I have the survey and maps, with the report of the surveyor and other reports. Here is the report of the engineer [producing]. I wish to say this, that this report is a mere synopsis, and that a complete report will be filed with the committee in the course of three or four weeks.

Our people raise in this valley, as a general thing, two crops a year; that is, two crops of potatoes, or a crop of barley and a crop of corn, or a crop of beans on some land. In planting the crops of potatoes they plant in March, and they will mature the last of June or first of July; and then they plant another crop in August, and they mature in October. In barley they seed in October, and it matures in June. They plant their corn in July, and it matures again in October.

The CHAIRMAN. At Florence, where you reside, is the land and climate suitable for raising grapes?

Mr. GUILD. I do not think there is a country that surpasses it in grape culture. The susceptibility of the soil there for raising grapes is extraordinary. There we have raised the finest grapes I have ever seen.

The CHAIRMAN. What other fruits do you raise; have you tried other kinds?

Mr. GUILD. We have fine orchards there of peaches, figs, dates, pomegranates, almonds and olives.

The CHAIRMAN. And those fruits can be raised all along through the valley.

Mr. GUILD. Yes. All the small fruits can be raised there, but the experiments in citrous fruits have not gone far enough to speak accurately with regard to them. But there is no country where the fig grows to such perfection as there. They raise three crops a year. In that report there is stated the amount of land that is under irrigation in that county, and it is 10,000 or 15,000 acres.

STATEMENT OF GEORGE W. BROWN, OF FLORENCE.

The CHAIRMAN. State your occupation.

Mr. BROWN. I am the editor of the Enterprise, a Republican newspaper. For information with regard to figures I shall have to refer you to the report. I heard the testimony of Mr. Guild, and from my own observation I can say he has given exact and correct information. There are some parties in the vicinity of Florence who are cultivating citrous fruits—the orange and lemon—and they give good promise. In the mountains near Florence, above, the orange and lemon have matured. There it is much higher than at Florence.

The CHAIRMAN. What is the height?

Mr. BROWN. About 1,500 feet. There is a large amount of land there that can be brought under cultivation by a reservoir at Butte Cañon.

The CHAIRMAN. Have you gauged the water?

Mr. BROWN. It has not been gauged accurately; but the river flows the year round.

Mr. GUILD. The water averages from 2½ to 12 feet in depth, and is in width 60 feet.

The CHAIRMAN. All the year?

Mr. GUILD. Yes. That would be the average for the year.

Mr. BROWN. There is more water in the canal at Butte than could be used. At that point it sinks in the sand and disappears. By constructing reservoirs at Butte and impounding the flood water we can have water enough to fill perhaps five times as many canals as we have in operation at this time, and do it the year round without any diminution of the flow.

The CHAIRMAN. What is the duty of water? How much does it take to irrigate an acre?

Mr. BROWN. I do not think that has been demonstrated there, because we have had such an abundance of water. There is no restriction upon its use; they allow it to flow all the time.

The CHAIRMAN. That will ruin the land.

Mr. BROWN. It has not done so up to this time. It is injurious, I know, but still the water of the Gila River at flood times carries down

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a sediment, a silt that fertilizes the land very much. Consequently, the more they cultivate and irrigate the land, the more fertile it becomes.

Mr. GUILD. I now present a set of photographs of the proposed reservoir site and dam at Butte, to accompany the map and report.

Mr. BROWN. So far as our climate is concerned it is very similar to the climate throughout the Gila Valley, with the exception that we do not have such extreme heat as they do in a lower altitude, although we have it hot enough.

The CHAIRMAN. Is it healthful?

Mr. BROWN. I think it is very healthful; one of the most healthful climates we have in this land.

The CHAIRMAN. Do you have consumption there?

Mr. BROWN. No. As far as my experience has gone, my health and that of my family has been better than it was in California, although I resided there a good many years.

STATEMENT OF J. H. STOUT, OF FLORENCE.

The CHAIRMAN. You may make a statement of what you know of this matter.

Mr. STOUT. I came out here last year for my health. I used to be the agent here for all the Indians in the Territory. I wish to say that the land is not better in Florence than it is in Phœnix, though the water is infinitely better. The water at Phœnix is brackish, and at Florence it is fresh. That is all I wish to say.

STATEMENT OF J. N. HURLEY, OF FLORENCE.

The CHAIRMAN. You may make a statement with regard to the irrigation about Florence.

Mr. HURLEY. The Gila River has two sections, the upper and the lower. The upper Gila River extends from the Black Range of mountains westward to the Buttes, some 400 miles; the lower, from the Buttes to the confluence with the Colorado River. These two sections, geographically, geologically, and climatic, you may say, are very different. In the upper portion a large area is covered with vegetation and timber growth, from mere brush of various kinds in the low lands to the most gigantic pines in the Black Range and Pinos Altos Mountains. In that portion of Arizona farming can be conducted without irrigation, having large rains in the summer season and heavy snow-falls in the winter. I have seen 3 feet of snow on a level. In the western portions all farming is conducted by irrigation, the rain-fall not having been sufficient to produce crops in any year from 1870. The upper portion of this lower section is the one in which I am interested. We have a large number of water-rights already established, and I file with you a map of the Territory, showing these water-rights at Mesa, Phœnix, and Florence. They are marked in red lines on the map. This map also shows the proposed reservoir site at Butte. That is marked in red. It also shows a proposed canal from that to the land that it covers. At Florence and in its vicinity we have water-rights that, including the Indian lands, are sufficient to irrigate, if properly cared for at this time, about 300,000 acres of land. Probably 50,000 acres of that are in the Indian reservation. Much of the land is not cultivated at this time, nor is it cleared up.

The gentlemen who have been examined filed a map showing this reservoir site at Butte, and I will file another that simply illustrates the same thing, but it will supplement the other. There can be constructed there a reservoir of large dimensions, at a distance of about 30 miles from Butte and the mouth of the San Pedro. This cañon varies in width from a quarter of a mile to a mile near Butte, and 4 miles long, with several cañons coming into it at various places. That reservoir will furnish water enough to irrigate a very large portion of the land that the gentlemen have referred to, south and west of Florence. The water-shed of the Gila River extends from Butte to the Black Range. Map No. 2, I file, shows this. In the Black Range and Pinos Altos Ranges there are unsurveyed lands with timber on them; but under existing regulations in the past years the timber has been cut off and destroyed, immense quantities of it, which is said to have been used in the construction of railroads, though taken ostensibly for mining purposes. There has been a large number of saw-mills running there, and they have destroyed vast quantities of timber. If that continues it will destroy our water-shed. Therefore the protection of this timber on the mountains is very desirable, the land not being fit for farming land. I would say that the Gila River has two annual rises; one in July and August, from the rains in the mountains, and one in February and March, from the melting snows in the Black Range of mountains.

The report submitted by Mr. Guild is as follows:

To the Special Senate Committee on Arid Lands:

SIRS: The undersigned committee, appointed by the board of supervisors to furnish data concerning the resources of Pinal County for submission to your committee, have been unable, through lack of time, to compile as complete a report as the importance of the subject demands, but beg leave to present the following statement of facts, with accompanying maps and photographic views, and to state that at a future date a more complete report will be submitted for your consideration.

We have the honor to be, with greatest respect,

RICHARD E. SLOAN, *Chairman.*
WILLIAM E. GUILD, *Secretary.*
JAMES M. HURLEY,
PETER R. BRADY,
WILLIAM H. BENSON,
JOSEPH H. KIBBEY,
GEORGE W. BROWN,
Committee.

FLORENCE, ARIZ., *August* 31, 1889.

POLITICAL ORGANIZATION.

Pinal County was originally formed from portions of Pima, Maricopa, and Yavapai Counties by act of the legislative assembly of the Territory of Arizona, approved February 1, 1875. In the year 1881 the Territorial legislature passed an act organizing the county of Gila from portions of Pinal and Maricopa Counties, leaving Pinal County bounded and described as follows, to wit:

Commencing at a point where the eastern line of range No. 1 east intersects the second standard parallel south, being the southeast corner of Maricopa County; thence east on the second standard parallel south to a point where such standard parallel south intersects the eastern line of range No. 18 east; thence north on the eastern line of range No. 18 east to a point where such line intersects the Gila River; thence down the Gila River to a point at the junction of the Gila River with the San Pedro; thence in a direct line to a point 250 yards east of the place where the Mineral Creek Mill stood in February, 1881; thence in a direct line to a mountain known as the "Water Shed," which lies about one-half mile east of Pinal Ranch; thence to a point where a direct line drawn from the Water Shed Mountain to where the mouth of Tonto Creek intersects the northern line of township No. 1 north; thence west on the north line of township No. 1 north to a point where such line intersects the eastern line of

range No. 7 east; thence south on the eastern line of range No. 7 east to a point where such line intersects the southern line of township No. 2 south; thence west on the southern line of township No. 2 south to a point where such line intersects the Gila River; thence down the Gila River to a point where such river intersects the eastern line of range No. 1 east; thence south on the eastern line of range No. 1 east to a point where such line intersects the second standard parallel south to place of beginning.*

By reference to the map it will be seen that Pinal is one of the central tier of counties, which embrace the largest area of farming land in the Territory. It contains 5,368 square miles or 3,435,520 acres, one-third of which could be made productive by a systematic storage of the surplus water now running to waste.

The Gila River enters Pinal on her eastern boundary, flowing southwest for 20 miles, where it is joined by the San Pedro River, which enters the county at its southeast corner. From the point of conjunction the river flows in approximately a western course for a distance of 82 miles to the western boundary of the county.

The San Pedro Valley lies on both sides of the river of that name and is 40 miles long by an average width of 2 miles. Not more than 10,000 acres of this valley have been put under cultivation.

From a point on the Gila River 5 miles west of the mouth of the San Pedro for a distance of 25 miles no farming is attempted on either bank of the river, and could not be made profitable if so attempted, owing to the narrowness of the valley, which in this place takes the form of a gorge varying in width from 1,000 feet to 2 miles, its narrowest point being at the buttes 15 miles east of Florence. From this point the Gila Valley proper begins and widens out rapidly, embracing all of the western portion of the county.

This valley can be irrigated from a storage reservoir located at the buttes economically and with an unfailing supply of water.

It embraces an area of 921,600 acres of irrigable land, the title to 90 per cent. of which remains in the United States Government. This land would come into market immediately should the Government take measures to supply it with water.

The population of Pinal County at the present time is about 5,000, but with the whole of the Gila Valley under cultivation it would support an agricultural population of 50,000 people, with an equal number in her cities and villages.

The following shows the assessed valuation of property for the past three years, with rate of taxation:

Year 1887, assessed valuation, $1,701,802.48; rate per $100 valuation, $2.70. Year 1888, assessed valuation, $1,830,170.30; rate per $100 valuation, $2.63. Year 1889, assessed valuation, $1,813,135.62; rate per $100 valuation, $2.75½.

It is confidently asserted that should the whole of the Gila Valley be put under a moderate degree of cultivation the assessed valuation of property would be increased to $20,000,000 and the rate of taxation correspondingly lowered.

PRODUCTS.

But very few years have elapsed since the industry of the farmer in this valley was solely directed toward the production of the few simple requisites of home consumption, and if its horticultural possibilities were thought of at all they intruded as pleasant dreams only.

Beyond the production of hay and cereals little advance was made until a few years ago, when experiments in fruit-culture were undertaken in a small way and with varied results.

Sufficient is now known to form the basis of intelligent calculation of the desirability and value of the many species in cultivation for the guidance of those about to cultivate land.

The grape is especially adapted to this soil and climate, and it reaches almost perfection in quantity and quality of growth. Unusual saccharine qualities are developed, which are especially desirable for table use and in rasin-making. Nearly every variety of grape so far tested grows luxuriantly in this valley, and it is clearly evident that raisin-culture is destined to become a prominent industry of the valley. Two and often three crops of grapes grow in a single season, and ripe grapes have been picked from the vines in limited quantities early in January, but such incidents are rare. The fig thrives remarkably well, bears heavily, withstands neglect, and is a source of great profit to growers. From two to four crops per year are gathered. It bears the second season and sometimes the first from the cuttings.

The apricot, peach, plum, prune, nectarine, pear, early apple, quince, mulberry, date, pomegranate, cherry, and all the small fruits and berries are grown, while almonds, walnuts, and pecans thrive exceptionally well. Culture of the citrus fruits has been undertaken only recently, and at this time it promises to become a success.

* Section 12, paragraph 366, Compiled Laws of the Territory of Arizona.

Several orange orchards will be planted the coming winter, and it is believed that a little care during the first season will insure their growth.

The absence of fogs and nightly dews is a formidable obstacle to the existence of the destructive and unsightly scale bug, and the fruits of this valley are all bright and clean.

The season is several weeks in advance of that of southern California, which gives fruit-growers an appreciated advantage in the early markets. All the usual agricultural products of the temperate zone are easily produced here, the long seasons giving a succession of crops that double or treble the productive value of the land. Wheat and barley are largely produced, although they are amongst the least profitable crops under the irrigating system. A careful estimate of the cost of carrying through to a marketable condition a field of wheat or barely, including rent on the value of the land, fixes $13 as the average.

Wheat yields about 1,500 pounds per acre, and therefore costs 85 cents per cental, and barley yields about 1,800 pounds per acre, and costs 75 cents per cental, leaving a very slight margin of profit.

Alfalfa is the most productive and profitable forage plant in the valley, and produces, under different conditions, from 1 to 3 tons of hay per acre at each cutting, and from four to six cuttings per year.

It costs to produce a cutting of alfalfa after it is well established as follows:

Irrigating per acre	$1.25
Cutting	.50
Stacking	.75
Cost per acre	2.50

In exceptional instances as high as 4 tons of alfalfa hay per acre have been cut, and five or six cuttings made in a single season, but this is more than double the average.

The home market afforded by the adjacent mining camps has consumed the surplus products of the valley in past years, but the constantly increasing acreage coming into cultivation will encourage the exportation of the large fruit product that must form the principal industry of the valley.

MINERAL HILL.

Going northwest from the town of Florence the course of the Gila River is traversed for some miles over an alluvial soil well watered and under cultivation. After leaving the river the country becomes broken into small hills of alluvial wash and conglomerate; the foot-hills proper of the mountains are underlaid with granite, through which veins of quartz traverse in a northwesterly and southeasterly direction. This quartz is associated with a high grade of cuperiferous ore.

The heart of this district where the mines are situated is porphyry, which has been pushed up through the granite underly, forming hills of very precipitous and rugged character in which the mineral-bearing leads are situated, having a trend from northeast to southwest, are well defined and in place, and can be followed with ease by their croppings which are very prominent to a great distance. These croppings are of quartz and iron and in many instances project themselves above the surface several feet in height. The district is remarkable from the ease by which a lead can be followed, in many instances some thousands of feet. These croppings are of themselves valuable ore, and are an unerring index of what exists underneath the surface.

In all instances the formation and leads are solid and in place, requiring little or no timbering; their position is such that they can be attacked easily and economically by either tunnel or level. Both formation and leads are very near a vertical, having but a slight pitch or inclination; the surface is covered to some extent with brush and grass with a plentiful supply of scrub timber sufficient for all fuel purposes. Mineral Hill presents the appearance of an immense porphyry out-crop surrounded by a semicircle of granite and syenite reaching from the northwest to the southeast of the district, cut by gulches of varying depth, in the principal ones of which there is running water most of the year.

IRRIGATING STATISTICS.

Practically, in Pinal County there are two irrigation districts, the Gila, above Florence, and the San Pedro country. I inclose a pencil tracing showing the relative location of the various ditches in and around Florence, prepared by Joseph H. Kibbey, superintendent of the Florence Canal Company, to whom I am indebted for the following data concerning irrigation in this county.

Beginning just below the cañon, about 12 miles above Florence, the ditches occur in the following order:

Name.	Length.	Acres.	Name.	Length.	Acres.
On the north side—	*Miles.*		On the other side—	*Miles.*	
Moore's	3	300	Brash	4	400
McClellan	3	300	Florence	43	60,000
Sharp	3	160	Montezuma	6	1,000
Stiles	4	300	Pat Holland	7	1,000
The Swiss	2	200	Alamo Amarilla	7	1,000
			Brady	4	1,000
			Adamsville	4	1,000
			White	3	200
			Walker and Dempsey	3	300

All the above ditches are private property, except the Florence, Montezuma, and Alamo Amarilla, which are incorporated.

There are three private ditches on the Gila above Riverside and below the San Pedro, as follows:

Name.	Length.	Acres.	Name.	Length.	Acres.
	Miles.			*Miles.*	
Shields	2½	480	Brennaman & Co	1¼	320
Winkleman	1½	480			

On the San Pedro, west side, and in their order up stream, are the following ditches:

Name.	Length.	Acres.	Name.	Length.	Acres.
	Miles.			*Miles.*	
Lattin	1	80	Bates	1½	160
Harrington	1½	480	Pusch	2	640
Swingle	2	480	Dodson	2	320
Waterman No. 1	1½	320	Cook	1½	200
Waterman No. 2	1½	320	Brown	1¼	160

These are all private ditches. About half of the land covered by the above ditches except the Florence is in actual cultivation. The Florence Canal Company has a capital stock of $500,000. The canal emerges from the river at a rocky point about 1½ miles below the cañon known as the Buttes. Eighteen miles of the main canal have been constructed and contracts for the remaining 15 miles have been made. Fifteen miles of laterals and service ditches are constructed. The main canal has a capacity equal to a flow of 440 cubic feet per second, and is so constructed that it can easily be enlarged and its capacity increased.

The company contemplates the building of storage reservoirs, one of which, at least, will be completed this summer. It will be situated about 15 miles south of Florence, will cost $100,000, and have a storage capacity of 8,000,000,000 gallons of water. There is a large catchment basin tributary to the reservoir, so that, with little trouble or expense, the reservoir can be filled at least once and possibly twice a year, independently of the river supply. There is in cultivation under this canal 6,000 acres.

The Florence Canal Company has in contemplation, as a part of its system, the construction of two reservoirs, one for storage purposes, about midway of the line of their canal, the other at the Buttes by means of a dam. This, however, will in no manner interfere with the construction of more extensive works that will furnish an abundant supply of water for a very large area of land not reached by their canal.

Adjourned.

The following statements were received and ordered filed:

REPORT FROM YAVAPAI COUNTY.

[Filed by the Governor, Hon. Louis Wolfley.]

In compliance with the request made by you in your letter dated June 3, 1889, the board of supervisors of Yavapai County issued a circular through the daily press, a copy of which is hereto annexed. The board regrets to say that not a single reply has been received by it from any individual or district directly interested in irrigation. The report of Lieut. A. O. Brodie, engineer in charge of the Walnut Grove Water Storage Company's property in this county, is herewith forwarded to you, with the prints accompanying the same. Will you please place them before the Senate committee?

Lieut. W. A. Glassford, United States signal officer, informs the board that all the information he is able to give has already been placed in your hands.

The lack of interest shown in this matter by the people of Yavapai County should not be taken as an indication of a lack of storage facilities nor of a scarcity of land which can be irrigated and be made valuable.

It is probably presumed that the natural advantages of Yavapai County and the necessities of the southern counties will cause the Senate committee to investigate for itself the vast possibilities which now lie dormant in our mountains and valleys.

The board of supervisors beg leave, through your excellency, to extend to the Senate committee a cordial invitation to visit the city of Prescott and county of Yavapai, and if this is accepted will place at the disposal of the committee every facility to enable it to investigate the subject-matter.

STATEMENT OF ALEXANDER O. BRODIE, OF SAHUARO, CHIEF ENGINEER OF THE WALNUT GROVE WATER STORAGE COMPANY.

[Made to the board of supervisors of Yavapai County.]

In reply to a communication from the clerk of your board of date August 7, 1889, containing copy of certain proceedings of the board, I have the honor to submit for your consideration the following remarks on water storage in this Territory, as exemplified in the successful establishment of a dam and reservoir by the Walnut Grove Water Storage Company.

This company has constructed on the Hassayampa River, 35 miles distant from Prescott, a dam of granite with outside walls 12 feet thick, the center being filled with loose rubble stone, covered on the upstream face with a skin of two thicknesses of 3-inch plank, a layer of tarred felt being placed between the two, the outside layer being thoroughly caulked and painted with paraffine paint, the joint along bed rock and at the ends being thoroughly cemented with hydraulic cement. This dam is 110 feet high, 135 feet thick at base, 12 feet thick, and 410 long on top line, and is built in a thoroughly solid and stable manner.

The water is carried through the dam for use by two 20-inch pipes placed in a tunnel cut through solid rock 80 feet below the top of dam, these pipes opening from a perpendicular tower, built out from the face of the dam, of 8 by 8 timbers well bolted together, with gates which can be closed at will, enabling the pipes to be cleaned. A waste-way has been cut through rock at the west end of the dam of dimensions 5 by 25 feet to carry off the overflow.

The batter, on the up stream face of the dam, is 68 degrees, with an apron or offset at 12 feet below the lower gate in the tower. About 9,000 yards of loose rock has been placed behind the dam and against the lower face as a precautionary measure.

The reservoir formed by the construction of this dam, when full, holds 4,444,534,864 gallons of water, covers an area of 527¼ acres, and receives the drainage of about 500 square miles of territory, mostly in a mountainous country subject to heavy snowfalls in the winter and to heavy showers during the summer months. Floods will fill the reservoir full at least three times during the year. The water-shed being of mostly bare of granite mountains, the water from melted snows and rain-fall very quickly finds its way to the river and is impounded in the reservoir.

Under ordinary circumstances the Hassayampa is but an insignificant stream, but rises to grand proportions during a heavy freshet.

The primary object in the construction of this dam and reservoir was to hydraulic certain bars on the lower river, with the ulterior one of conducting the water stored out on the desert for irrigating purposes. The successful prosecution of the work has shown conclusively what can be done in the way of water storage in Arizona, as it is to be supposed that that which can be done on one small stream subject to freshets can be done on almost all others, reservoir and dam-sites being equally available.

This company is at present engaged in the construction of a service dam 14 miles below the reservoir, to which point the water is allowed to flow down the river-bed, when it is to be raised 32 feet into a flume.

I have not in my possession sufficient data from which to give the cost of construction of the main dam, but should judge that it would reach to nearly half a million dollars.

Any extended system of irrigation inaugurated in this Territory must almost wholly, from the nature of the country, depend upon water storage for its success. Artesian water may yet be found, though it is doubtful, while pumping water from wells for the purpose of irrigation is a costly experiment.

All streams flowing from the mountains to the plains are subject to heavy floods, the waters of which if stored in proper reservoirs would be sufficient to reclaim many thousand acres of desert land, utterly worthless without irrigation. Such a system inaugurated on the Agua Fria would reclaim land equal to any in the Territory. On this stream and its tributaries three large reservoirs could be constructed, from which the water would flow in the river-bed to the head of the necessary canal, at which point a small service dam would divert the water from the channel into the canal and thus to the land to be reclaimed.

Suitable sites could be selected on the Verde, the Salt, Tonto Creek, the Gila, and the San Pedro for reservoirs, which, if constructed and the water flowing in these streams during floods, now going to waste, impounded, would more than quadruple the amount of water now taken from them for irrigating purposes. Nearly all the available land in Arizona can be reclaimed by a proper system of water storage.

STATEMENT OF EDWARD B. MOSELEY, ASSISTANT SURGEON U. S. ARMY, OF FORT WHIPPLE, PRESCOTT.

In the popular mind the name of Arizona has been so long associated with torrid heat, lawless whites and hostile Apaches, venomous reptiles and poisonous insects, that anything that may be said in favor of this Territory as an agricultural region will be received with doubt and considered with prejudice. It is a fact, however, that large portions of this Territory have advantages in salubrity of climate and productiveness of soil so great that in time a great and prosperous community will live and flourish in what is now popularly known as the desert. These changes have already commenced, and, destined to rapid increase, have been effected by means of irrigation or the artificial application of water to the soil. It is the oldest system of tillage known to man. The water being at all times under the control of the cultivator, lands where this system is pursued support a dense population, for there is no failure or partial failure of crops. Through irrigation 9,000,000 acres of land in Algeria have within a few years past been reclaimed, and the arid belt of Arizona, long known as part of the Great American Desert, is rapidly being changed into a great farming and fruit region. Those who have not seen or studied irrigation have no idea of its advantages. Any farmer would consider the value of his land doubled if he could have the power to cause the rains to come to his fields in such quantities and at such times as he should direct. Almost exactly this power is held by the cultivator who lives in an arid region. He makes his own weather; he is almost independent of the clouds, as far as his own particular portion of the country is concerned. The water he uses is annually gathered from the sides of the mountains, scores and hundreds of miles away. This is an established fact. There are now thousands of acres, principally in the valleys of the Salt and Gila Rivers, bearing crops that rival in luxuriance those of the valley of the Nile. The amount of land which will be reclaimed in the counties of Maricopa, Pinal, and Yuma when the canals now in process of construction are completed, will probably approach 1,000,000 acres. How far the water-supply can be extended is a matter of much importance. In India and Spain one-third of the arable lands are cultivated by impounding the waters of the storm floods. Thus far, with the exception of the water-storage reservoirs built at Walnut Grove, Yavapai County, nothing has been done in this direction in Arizona.

The Gila and Salt Rivers during the flood season pass enough water into the Colorado River to increase the amount of reclaimed land three or four fold. In both these rivers are cañons which make almost natural storage reservoirs where, by building dams, the flood-water could be impounded and made to do its duty in adding millions of acres to the arable dominion of the Territory. On this subject I quote Lieutenant Glassford, of the United States Signal Corps, who says:

"The table of the average monthly rain fall shows the distribution to be plenty in the mountains and almost none in the so-called desert valleys. It should not fail to be noted in connection with the rain-fall that the points of observation are not on the tops of the mountains nor high up on their slopes, but in the most cases in valleys or cañons. It is no uncommon sight to observe heavy rains on the summit of ridges, and from them flows great volumes of water, while at the point the rain-guage is

located perhaps not a sprinkle would fall. It is for this reason that the data only represents the least approximate quantity of the actual rain fall. Admitting that sufficient water falls upon the elevated plateaus of Arizona, it remains only to collect it in reservoirs and distribute it by canals to change the delusion of the mirage into the actual delights of the oasis. The observing traveler is also forced to note the jutting stone walls of cañons, forming natural abutments for storage dams, between which these mountain streams flow. By artificially completing these partial dams the immense supply of water that now pours in floods and later sinks in sandy channels would be preserved for the soil that only awaits its influence to bring forth abundant harvest."

The productions of these arid or desert lands when artificially supplied with water include every variety of vegetation, cereals, grasses, fruits, flowers, trees, shrubs, and vegetables known to the semi-tropical zone. There is not a month in the year when fresh vegetables and fruits can not be had in the Salt and Gila Valleys.

Grain yields from 2,000 to 3,500 pounds per acre; deciduous fruits from three to four years old an average of 100 pounds per tree; and all fruits ripen in this section from two to four weeks earlier than in Southern California. Grapes are especially a productive and profitable crop. In Yuma and Maricopa Counties they ripen several weeks earlier than in California, while the yield is fully as large. The climate is particularly adapted to the production of raisins, owing to the absence of rain, fog, and dew during the drying season, and many thousands of raisin-grape vines have been set out during the past two years. Alfalfa, being the most profitable, has supplanted all other grasses. Besides the large quantities grazed there is cut in the Salt River valley annually 60,000 tons, which is fed to cattle on the spot or shipped to supply the different towns and mining camps in the Territory. With additional railroad facilities this crop will be much increased.

Irrigation is no new thing in Arizona. The recent developments made by Mr. Frank Cushing, under the authority of the Smithsonian Institution and the patronage of Mrs. Hemingway, of Boston, proves beyond question that, centuries ago, the Salt River Valley contained a population of probably 300,000 souls supported by agriculture. There can be traced to-day upon the surface their ancient water-ways, through which in the past water was applied to the soil of that valley, and by farming support was furnished to over a quarter of a million people. The valley of the Gila shows the remains, if anything, of larger and more elaborate systems of irrigation. Thus is established that the agricultural resources of Arizona were recognized and utilized by a pre-historic race of industrious and progressive people. It has been estimated that in the valleys of the Colorado, Salt, and Gila Rivers there are fully 2,000,000 acres of arable land. These rivers carry an abundance of water to reclaim all these lands, but irrigating canals and storage reservoirs must be constructed.

It is gratifying to note that Congress has taken action on the subjects of irrigation and the reclamation of desert lands by making an appropriation to commence surveys for the establishment of locations for storage reservoirs and canals. This is a most important question, vitally affecting the future of Arizona. There are here fully 25,000,000 acres of land, the most productive on the continent, which, if they can be reclaimed, will make homes for 1,000,000 people. The remarkable fact that agricultural land is actually becoming scarce in the United States is at last becoming apparent, and the assistance of the General Government in bringing the so-called desert lands of the Southwest into a condition to support in comfort, by agriculture, a portion of the crowded population in the eastern portions of the country is greatly needed. Great advances have been made by the enterprise of the citizens of this region who have by their labors under great difficulties turned a portion of the desert into an oasis, but to fully develop the country is required the expenditure of large amounts of money in the building of storage reservoirs by means of which the lands already redeemed can be preserved from the effects of occasional mid-summer droughts, and many thousands of additional acres put under cultivation and made the homes of man. The establishment by the Government of the facts that the precipitation of moisture during the year is sufficient, if preserved and used for irrigation during the dry season, to make an absolute certainty of all crops that were put in and the location of the proper places for the dams to hold this great supply of water that now goes to waste would result in the erection of these works by capitalists from other sections of the country, foreign capital being now timid and the enterprise being too costly for the energetic and hard-working population who have settled in and, so far, remarkably developed the country by the canal systems which have been within their ability to perfect.

The Indian question, so long the bugbear which prevented the development of this Territory, now happily quieted by the successful exertions of the Army, would become entirely a thing of the past were the desert lands placed in a condition to support the population of agriculturists that would so rapidly flock to them were the internal improvements in the way of reservoirs and canals completed that have been so well commenced by the act of Congress in providing for the preliminary steps of survey and hydrographic engineering.

TUCSON, ARIZ., *September* 5, 1889.

The committee met pursuant to call of the chairman.

Present: Messrs. Stewart (chairman) and Reagan; also Director Powell.

STATEMENT OF F. H. GOODWIN, OF TUCSON.

The CHAIRMAN. Have you made any report with regard to irrigation in this Territory?

Mr. GOODWIN. Yes.

The CHAIRMAN. Have you it here?

Mr. GOODWIN. Yes.

The CHAIRMAN. Will you file it with the committee?

Mr. GOODWIN. With your permission, I will do so.

The CHAIRMAN. State generally what the report contains.

Mr. GOODWIN. It contains the opinion of our people as to the possibility of the reclamation of our arid lands, what the land produces when irrigated, and the fact that it has no value without irrigation. It also shows the feasibility of locating sites for reservoirs, and gives the results of fruit planting in the portions of the county irrigated.

The CHAIRMAN. What streams have you in this county?

Mr. GOODWIN. We have besides the Santa Cruz—our most important river—a small mountain stream in the southern portion called the Sonoita. It carries a good deal of water at flood seasons. There is also the Arivaca and the Babaquivari.

The CHAIRMAN. Is there much irrigation going on in the county?

Mr. GOODWIN. Comparatively little. We have probably 4,000 acres of land that could be irrigated, and have nearly that much under irrigation.

The CHAIRMAN. What crops do you raise here?

Mr. GOODWIN. Without irrigation we raise none; with irrigation we raise corn, barley, rye, wheat, alfalfa, lucern, potatoes, beans, and sorghum; in fact, all the grains, and all sorts of fruit from the peach to the olive, and all kinds of berries.

The CHAIRMAN. Do you raise oranges here?

Mr. GOODWIN. Yes; we have here, within 15 miles of this town, oranges growing nicely, but they are an experiment yet. We can not say that we grow oranges, but we know that the other fruits produce large crops.

The CHAIRMAN. Does your report designate the points where water could be stored?

Mr. GOODWIN. Yes; not so fully, though, as we intended, because the time given was short. We have surveyors, however, now looking for locations, and we propose to forward to your committee hereafter the information they obtain, if we are permitted to do so.

The CHAIRMAN. We would be glad to receive it. Are those locations for reservoirs on public or private land?

Mr. GOODWIN. On public land, as we understand it. One portion of the basin will probably cover land for which the United States has given a patent to an individual. We have thirty-six irrigating ditches covering 3,000 acres of land, aggregating 56 miles in length. There are several canals now in course of construction. Two of them are of considerable magnitude. One is at Santa Cruz and one near town. We expect to irrigate all this table-land that you see around here.

The CHAIRMAN. Has irrigation ever been practiced to a larger extent than it now is by the people who resided here before?

Mr. GOODWIN. Yes; we find the ruins of their canals, ditches, and reservoirs everywhere. On my farm the lines of the old irrigation works traverse quite a considerable part of it. I sold my farm recently, however, and should not now speak of it as mine. The water taken on it is taken from the Santa Cruz, but evidently the water taken on it in past ages was water from the plain.

The CHAIRMAN. Have you any evidence as to the period of time when those ancient works were constructed?

Mr. GOODWIN. No; though we know that it must have been in the stone age, as we find implements of stone—the axe and hammer, etc.

The CHAIRMAN. Are there any traditions among the Spaniards here as to the irrigating works?

Mr. GOODWIN. None whatever. They were built by a race entirely unknown to the Indian tribes who now inhabit this country. The Mexicans have no traditions whatever on the subject. There are no remains except the hieroglyphics on the rocks and the stone implements to which I have referred.

Senator REAGAN. Has anybody ever been able to interpret those hieroglyphics?

Mr. GOODWIN. No. You find the hieroglyphics all around here, some of them on the edge of Tucson, half a mile from the city.

Senator REAGAN. Then, from the ruins which you say exist, it is probable that this part of the county was once densely populated?

Mr. GOODWIN. We hold that all this valley and all this table-land at one time supported a dense population. We have irrigating ditches that were originally created in 1690.

Senator REAGAN. Does the land produce as good crops as it ever did?

Mr. GOODWIN. Yes; I think better.

Senator REAGAN. There is no failure of crops?

Mr. GOODWIN. None, when we have water enough.

Senator REAGAN. Have you made an estimate of the amount of land about this valley that can be irrigated?

Mr. GOODWIN. Yes; we think about 2,000,000 acres can be irrigated. We take our estimates from the surveys made by the United States surveyors. Where the land has not been surveyed we take them by general measurement.

Senator REAGAN. You think you have water enough to irrigate that much?

Mr. GOODWIN. Yes. It was done before. The lines are plain to show where it was done. In very few instances can we trace the canal to its source—to the reservoir where it was filled.

Senator REAGAN. What amount of wheat can you produce here from irrigated land?

Mr. GOODWIN. Thirty to 40 bushels to the acre. Under favorable conditions we can produce 40 bushels.

Senator REAGAN. State what you get of cereals and other crops?

Mr. GOODWIN. We get 400 bushels of potatoes to the acre, 50 bushels of corn, 40 bushels of wheat, and 40 bushels of barley under ordinary cultivation. The yield would be greater with improved implements and conditions. I desire to state that we here hold that our country is peculiarly adapted to the growing of fruits—the peach, apple, quince, pear, pomegranate, and olive—in fact all the fruits that grow in tropical countries; and our fruit has as good flavor as any fruit ever eaten.

The following is the paper referred to by Mr. Goodwin:

REPORT ON PIMA COUNTY.

The citizens of Pima County, Ariz., have the honor to present to you the following facts and statistics in connection with the reclamation of arid lands in this county. Examination shows conclusive evidence that all level lands in southern Arizona have at one time been cultivated under a system of irrigation by storage of water in reservoirs, the remains of which, as well as of the ditches and canals conveying water onto these lands, are yet to be seen and can be traced for long distances. And at this day, when the farmer commences the cultivation of new lands, his plow turns up stone implements used by a long-gone race of men, who tilled the soil which we now use, seeking to reclaim again from the desert. The ax, hammer, lamp, and the hand-mill, etc., of stone, and the earthen vessels for household purposes are common and can be seen in almost every house. Beyond all question the whole of southern Arizona teemed with a dense population whose pursuits were wholly agricultural. The arid lands of our county were cultivated by a people who thoroughly understood the value of irrigation. Who they were we know not. The only record left by them is the remains of their canals and reservoirs and the hieroglyphics on the rocks, which doubtless, if they could be deciphered, would tell of a prosperous people. The skilled engineer of to-day finds in constructing his ditches and levels frequent occasion to utilize the labors of this long-forgotten people, who carried water where he now seeks to do the same.

The climatic conditions of southern Arizona are such now as doubtless they were then, that without irrigation agricultural pursuits can not be followed. This fact was recognized by the missionary fathers, who in the year 1690 settled in this valley. They, before building churches, taught the Indians how to build dams and reservoirs, three of which—El Cumoso, Missional, and Del Rey—are in use to this day, irrigating in part the same lands which have been under continuous cultivation for two hundred years. Much of this land has grown two crops each year during the whole period.

There are in the valley of the Santa Cruz River and on the table lands lying in the great basin between the Santa Rita Mountains on the south and the Rincon Mountains on the east, the Santa Catalina Mountains on the north and the Amole and Sierrita Mountains on the west, over 1,000,000 acres of arid land which are arable and can be brought under cultivation by making dams at points which are more fully shown by maps and measurements made by this committee for your information. We call your attention especially to the map of a proposed dam at a point about 25 miles southeast of Tucson, which alone, if built, will bring under cultivation more than 100,000 acres of good land which now lies idle and unproductive. All this land is now of practically no value, as no crop can be grown thereon without being irrigated.

Sites for reservoirs can be found at various points on the east and west sides of the Sierrita Mountains. There is a very fine site for a reservoir northeast of the United States military reservation at Fort Lowell, 7 miles from Tucson, at the Sabino Cañon, which has storage capacity for several billion gallons of water, sufficient to irrigate all the land lying to the east and north of Tucson, in the basin spoken of before.

This committee finds by consulting the best authority (United States surveys as far as made and by measurements where not made) that

there are over 2,000,000 acres of the best of land in this county lying idle for the want of water to irrigate it. That this water can be stored there can be no doubt. The average rain-fall for five years, as shown by the report of Mr. E. R. Wetmore, in charge of the United States meteorological station at Tucson, is 11.71 inches in the valley. The precipitation on the mountains is more than four times as great as it is in the valley, where the station is established.

The probable cost of constructing dams, reservoir, and canals to bring these lands under cultivation will not exceed $1,000,000. The lands at present are of no value, but if by means of storing the rain-fall they can be irrigated they become at once valuable for all times. Our lands are adapted to the growth of all the fruits of the temperate and semi-tropical regions. The peach, pear, apricot, nectarine, pomegranate, apple, quince, fig, olive, and the plum do exceptionally well and produce the best of fruit, which ripens a month earlier than in California. The grape grows thriftily and often gives two crops per year, and ripens at a time when we have no rain, so enabling us to convert the grapes into raisins at a nominal expense. Under favorable conditions the product of lands well cultivated is as follows: Barley yields 50 bushels per acre, wheat yields 30 bushels, and corn 50 bushels per acre, potatoes 400 bushels, and beans 40 bushels per acre. Barley and wheat when sown for hay return an average of 2 tons per acre. Alfalfa (lucern) after being well set, can be cut six times per year, yielding in the aggregate 12 tons per acre. Hay is worth $12 per ton; grain 90 cents per bushel, and potatoes $1.20 per bushel.

If the Government will make the necessary surveys and withdraw from entry and settlement only the lands embraced in the basins of the proposed reservoirs, private enterprise will, we think, soon solve the problem of water storage in Arizona, increasing the value of lands from nothing to an assessed value of $50 per acre. (The lands in the vicinity of Tucson, under cultivation, being irrigated, are now assessed for taxes at $50 per acre.) Where lands are thoroughly cultivated experience shows that 1 miner's inch is sufficient to irrigate 6 acres of land, which, when planted to grain, beans, hay, or fruits, need to be irrigated once in thirty days. For alfalfa land should, to produce the best results, be irrigated every fifteen days, requiring 1 miner's inch for every 3 acres.

The castor bean grows here to be a tree reaching 6 inches in diameter and a height of 15 feet, yielding 2½ bushels of beans to the tree. The tree, when protected, lives four or five years.

There are in all 12,000 fruit-trees in bearing, producing the best of fruit, full in size and delicious in flavor. There are 3,000 grape-vines in bearing, with 1,500 cuttings one year old. The grape comes into bearing in three years from the planting of the cutting and in two years from the planting of the rooted vines.

The culture of fruit in this county is an entirely new enterprise, and from the success attained by the experiments made bids fair to become one of the chief industries of this section.

In the valley of the Santa Cruz, from Calabasas to Tucson, there is under cultivation about 3,000 acres, yielding—

5,628 tons of hay	$67,536
844,000 pounds of corn	12,675
1,374,000 pounds of wheat and barley	20,601
300,000 pounds of potatoes	6,000
280,000 pounds of beans	8,400
300,000 pounds of vegetables	15,000
26,000 pounds of red pepper	1,680
Total value of product	131,901

On the Rillito Creek, east of Tucson, 500 acres of land are under cultivation, producing—

850 tons of hay	$10,200
265,000 pounds of barley	3,975
80,000 pounds of beans	2,400
100,000 pounds of potatoes	2,000
Total value of product	20,575

At Crittenden, Redington, and other points lands are cultivated to some extent with the same results as reported above. There are thirty-six ditches, of a total length of 52 miles, used in irrigating these lands. The above products were grown from July, 1888, to July, 1889. The grain and potato crops were planted in 1888, the hay 1889, as our lands produce two crops a year, sowing grain in December and January and corn, beans, and potatoes in July and August, harvesting hay and grain in May and June, and other crops in October, November, and December, excepting alfalfa hay, which is cut each month from April to September. During the months of October, December, and January alfalfa fields are pastured, it keeping green and growing slowly during three months. This crop is destined to be the great hay crop of Arizona.

This committee has received protests from prominent men in all sections of the county against the repeal of the desert land act, so far as Arizona is concerned. Arizona being wholly arid, and having been largely benefited by the reclamation of arid lands under this law, we most respectfully ask you to lend us your aid in preserving this law.

We append the report of one of our best orchardists, which gives in detail the method of cultivation and the product of fruit-trees in this section.

Respectfully submitted.

FRANCIS J. HEUEY, *Chairman.*
JOHN A. BLACK.
BREWSTER CAMERON.
F. H. GOODWIN, *Secretary.*

SAN RAFAEL RANCH,
Lochiel, Ariz., August 14, 1889.

SIR: Yours of the 13th instant just received. In the next mail I will send you all the data I can. Will copy down number and varieties of trees in the large orchard; also the number and varieties I have, how many in bearing, age, etc.; all of interest that I can. If there is any part you do not wish to use, cut it out.

One nectarine tree had on it, by actual count of Colin and myself, eighty-four nectarines, every one perfect; one, thirty-two, and seven other trees from one dozen up to two dozen. The largest nectarines measured 8½ inches around, from stem end to blossom end, and 7½ inches around the other way. I did not weigh any; am very sorry I did not. I think there are some pretty large ones on the trees yet. If there are, will weigh and tell you.

Four peach trees have quite a good many on; two not many. The ones on the four trees I think will be very fine in size.

I think it will be very interesting to know of the success of fruit-culture, etc., in our county, and after all is reported and gotten together I would be much pleased to know the result of inquiries.

Respectfully,

ALICE F. CAMERON.

Hon. F. J. HEUEY,
Chairman Citizens' Committee, Tucson, Ariz.

San Rafael Ranch.

[Orchard planted by Mr. Brewster Cameron, 1888.]

Varieties.	Total.	Dead.
Apple (summer, fall, and winter)	34	None.
Apricot (assorted)	15	None.
Cherry (early and late)	12	None.
Fig (white Adriatic)	2	None.
Nectarine (assorted)	9	5
Olive	6	None.
Peach (early and late)	24	4
Pear (assorted)	16	1
Pomegranate (assorted)	8	4
Prune (assorted)	10	2
Quinces	2	None.
American mulberry	2	None.
Almonds	3	None.
English walnut	10	1
White walnut (butternut)	2	2
Filberts	2	None.
Italian chestnuts	2	None.
Pecan	2	None.
Total	176	20

[Fruit trees planted 1889.—Alice F. Cameron.]

Apple (summer, fall, and winter)	38	None.
Apricot	2	None.
Fig	5	2
Olive	1	None.
Peach (assorted)	6	1
Pear	5	None.
Plum	4	None.
Russian mulberry	1	None.
English walnut	3	None.
Paragon chestnut (American)	2	1
Total	67	4
GRAPE VINES.		
Eastern:		
Brighton	2	
Concord	2	
Warden	2	
Wyoming red	2	
Total	8	None.
California:		
Muscat of Alexandria	10	
Black Prince	4	
Golden Chasselas	3	
Total	17	2
Planted in 1889	92	6
Planted in 1888	33	None.
Total	125	6

[Fruit trees planted in spring of 1888.]

Governor Wood, in 1889 bore 1 pint very fine large cherries	1	None.
Sweet cherry trees, Napoleon	1	None.
Sour cherry trees:		
May Duke	1	None.
Empress Eugenia, in 1889, bore over 1 pint of finest large sour cherries I ever saw, rich and good	1	None.
Bartlett pear	2	None.
Peach	6	None.
Nectarine	9	None.
Peach or nectarine	12	None.
Total	33	None.

The above peach and nectarine trees I raised from seeds sent to me by General Simon Cameron, of Harrisburg, Pa. I received the seeds in the fall of 1884 and planted them at once (in September). The young trees came up in the spring of 1885. I cut them back and transplanted them in 1888. In 1889, at four years of age, nine of these trees bore as fine nectarines as I have ever seen or tasted.

NOTES ON FRUIT.

The color of fruit, a dark purple red; flesh, greenish white, very delicious. Pit quite small. The other trees ripened their fruit from one to two weeks later. Fruit yellow, shaded bright dark red; flesh yellow white, very slightly tinged with green; very fine.

June bugs, and a small bug or beetle, gray with some red on it, were very destructive to this fruit, eating voraciously at the nectarines as soon as they could find the fruit begin to soften. On two nectarines there were twenty-three June bugs caught and killed.

Six peach trees are now in bearing, raised from seed sent me by General Cameron. The fruit is very smooth, and increases fast in size—promising to be exceedingly fine fruit. The trees have been kept trimmed to low, bushy heads. Each year they will be trimmed back half of the previous year's growth. Without an annual shortening-in, the peach is a short-lived tree. To prune them carefully and judiciously keeps them in bearing many years.

I do not know the names of the varieties of the peaches and nectarines of which I planted the seeds, the trees from which are now bearing. General Cameron said that it was exceedingly fine fruit.

In this locality I find the mulberry, apricot, nectarine and peach trees, and grape vines, make the most luxuriant growth. (The apricot trees planted this year, 1889, have made a growth of very nearly 6 feet. The grape vines have grown some 4 feet, some 8 feet.)

Next follow the apple and cherry, figs, pear, and plum. English walnuts and the chestnuts grow rapidly. For every tree and vine I had holes dug 3 feet in diameter and 2 feet deep.

The climate and soil are fine, and will, with most ordinary care, produce a good crop of fruit each year after the trees come into bearing. With good care, watchfulness, and careful pruning, the fruit-yield will be simply enormous.

In California grape vines are so trimmed that they are self-supporting, no trellises being used as a general thing, the vine growing thick and kept to within a few feet of the ground, the bearing branches each year spreading out and drooping over, so that some of the bunches of grapes rest on the ground and ripen there.

This system of culture, I am satisfied, will not do for Arizona. The rainy seasons for California and Arizona come at a different time of the year. Our rains come when our grapes begin to ripen, or rather before, but last up to and into September. The ground is hot and moist; this with the midday heat will, I believe, rot every bunch of grapes that touches the ground. I think vines will do better trained up about 5 feet or even less. Posts and smooth wire will make good trellises.

I irrigate my fruit trees and vines with a hose in midsummer once every two weeks. In spring and early fall once a month.

No rose plants, even of the most delicate and tender varieties, need any winter covering. I have a bed of thirty choice varieties which bloom with great profusion from early April to late November.

ORCHARDS IN COCHISE COUNTY.

Three years ago Mr. William Graeff, who resides at the foot of the west Huachuca Mountains, planted seventy-five fruit trees and about thirty-five grape vines. This year the trees were heavily laden with fruit, except the apple and pear trees, which are slower in growing to maturity in this country, as well as in the east or in California. He planted apple, pear, plum, apricot, cherry, and peach trees.

Among the grape vines he has the flame-colored Tokay, Muscat of Alexandria, Black Hamburg, Mission, and White Hamburg. These grape vines were laden with magnificent bunches of as fine grapes as I ever saw or tasted anywhere.

Mr. Graeff pipes his water for irrigation from a spring about a quarter of a mile from his orchard. The water runs into two large wooden troughs, or as he calls them tanks, from there into his orchard; the water of course can be turned off or on at will in the orchard.

The apricot and peach trees yielded particularly large crops. The fruit was of large size and of the finest flavor.

About five miles farther north along the same range of mountains is a fine orchard of Messrs. William Simmons and B. F. Heslep. These gentlemen set out their orchard two years ago. They bought their trees in California. At the time of planting these trees were two years from the graft. The orchard consists of two hundred trees of the following kind: One hundred peach trees; twenty cherry trees; twenty pear trees; twenty plum trees; twenty apricot trees; twenty apple trees. The orchard is irrigated by water run in through shallow ditches from a spring quite close by. The holes for the trees were dug 2 feet deep and nearly 3 feet in diameter,

Remembering that this orchard was planted only two years ago it is simply astonishing what an enormous crop of fruit was harvested this year.

Among the peaches the early Crawford, and a superb white flesh crimson covered peach, were the best of the early variety. No California orchardist could possibly show better specimens of fruit of the varieties these gentlemen planted.

The land on which this orchard is planted was very stony, not only small stones but in many places good-sized rocks. Many wagon loads of rocks were hauled away and many remain, though more will be taken off. The land is fine and rich since irrigated.

Among the trees bearing fruit this year the peach and apricot bore the heaviest crop.

I believed that grapes must be grown on trellises in Arizona, owing to our rainy season coming at a different time to that of California, but since visiting Mr. Graeff's place I am convinced that trellises are not a necessity, as Mr. Graeff has his vines tied to stakes. The body stem of the vines is about 24 inches high; from this height of stem the yearly growth sprouts out and hangs over, umbrella shape.

The fruits of these two orchards were sold in Tombstone, Bisbee, Harshaw, and other places. Every pound of fruit brought 8 cents, whether sold at home at the orchard or taken away to be sold, and ready sale was found for every pound.

STATEMENT OF A. J. DAVIDSON, OF TUCSON.

The CHAIRMAN. What is your occupation?

Mr. DAVIDSON. I have been constructing ditches, and working in that line.

The CHAIRMAN. Are you an engineer?

Mr. DAVIDSON. Yes; a constructing engineer.

The CHAIRMAN. Are you familiar with the water courses of this district?

Mr. DAVIDSON. Yes; I have made them a study.

The CHAIRMAN. And with the quantity of water?

Mr. DAVIDSON. Yes. Most of these streams are underground.

The CHAIRMAN. From where does the supply come for the streams in this vicinity?

Mr. DAVIDSON. From the water-sheds of the mountains.

The CHAIRMAN. Describe generally, and in brief, the water-sheds that supply these streams?

Mr. DAVIDSON. Stating it roughly, the Santa Cruz water-shed is 120 miles in length by, perhaps, 60 miles in width. The Rillito has a water-shed of about 75 miles to 80 miles in length by 30 miles in width. Then there are smaller streams also.

The CHAIRMAN. What is the general altitude of the mountains that furnish these streams.

Mr. DAVIDSON. Ten thousand to eleven thousand feet.

The CHAIRMAN. Does snow fall on them?

Mr. DAVIDSON. Yes; in the winter time.

The CHAIRMAN. What is the amount of precipitation generally?

Mr. DAVIDSON. 11.77 inches in the valley.

The CHAIRMAN. I mean how much in the mountains?

Mr. DAVIDSON. We have no witnesses on that point.

The CHAIRMAN. You say most of those streams are underground. Explain what sort of streams they are?

Mr. DAVIDSON. For instance, the Rillito has an average fall of 20 to 21 feet to the mile. Our process of taking out that water is by commencing at the surface, at a grade of 3 feet to the mile, and tapping this underground stream. We get a great deal of this water underneath. It is a problematical question as to how much is water and

how much gravel underground, but we know there is a good deal of water.

The CHAIRMAN. What amount of water did you get in your experiments?

Mr. DAVIDSON. As far as we have completed the work we have 6.4 feet of water. These underground streams are quite wide. For instance, by running a line of levels we find that the Rillito is 1½ miles in width underground.

The CHAIRMAN. At what depth is it?

Mr. DAVIDSON. We generally encounter this water at the dryest time at from 5 to 9 feet under the surface. It varies, of course.

The CHAIRMAN. Then you are engaged in getting that water to the surface?

Mr. DAVIDSON. Yes.

The CHAIRMAN. What effect does evaporation have on those streams, they being underground?

Mr. DAVIDSON. We consider that the fact of the streams being underground is an advantage. It is a wise provision of nature that they run below. We have constructed 1,300 feet of concrete aqueduct, and we propose to extend that by redwood aqueducts. We will then have supply leads running into those aqueducts.

The CHAIRMAN. You will go to the bedrock?

Mr. DAVIDSON. There is no bedrock.

The CHAIRMAN. What is beneath the stratum that furnishes the water?

Mr. DAVIDSON. It seems that there is not even a rudimentary bedrock; there is not the commencement of a bedrock.

The CHAIRMAN. No clay?

Mr DAVIDSON. No; only in spots.

The CHAIRMAN. What holds the water, then, from sinking down?

Mr. DAVIDSON. This entire country here seems to be underlaid with gravel and sand.

The CHAIRMAN. To what depth?

Mr. DAVIDSON. We do not know.

The CHAIRMAN. Have you sunk wells to see?

Mr. DAVIDSON. Yes; and as deep as we go we find the same material. We have gone 16 feet below the lowest water level that we have—that is as deep as we could go—and we found the same material—gravel and sand.

The CHAIRMAN. And water?

Mr. DAVIDSON. Yes, and water. That is the trouble about damming. There is nothing to pin a dam to at the sides or bottom.

The CHAIRMAN. You mean in the Rillito?

Mr. DAVIDSON. Yes. In the same work on the Santa Cruz we find the same conditions existing. When we encounter this water level we encounter this same material—gravel and sand. There is nothing, therefore, to pin a dam to, so that the only way to get water is to lead the water out.

Senator REAGAN. Do you mean lead it out from where it leaves the foot-hills?

Mr. DAVIDSON. No; lead it out into this channel.

Senator REAGAN. Where do you commence?

Mr. DAVIDSON. In the bed of the stream—out in the mesa, for instance, and running right along.

The CHAIRMAN. You go on in the stream until you get down deep

enough to get water, then you cement your tunnel, and then run lateral tunnels.

Mr. DAVIDSON. Yes.

Senator REAGAN. You meant tunnels instead of ditches?

Mr. DAVIDSON. Yes; we tunnel until we get into this water stratum.

Senator REAGAN. How do you construct a tunnel, of what material?

Mr. DAVIDSON. The last part of our tunnel will be a cylinder made of redwood with iron bands.

The CHAIRMAN. Have you sunk wells here to test it?

Mr. DAVIDSON. Yes.

The CHAIRMAN. To what depth?

Mr. DAVIDSON. From 5 to 9 feet in the river channel.

The CHAIRMAN. That is hardly a well.

Senator REAGAN. Are your lateral tunnels made of wood?

Mr. DAVIDSON. Yes.

Senator REAGAN. How do you get the water into them?

Mr. DAVIDSON. We put in percolating timbers, so as to let the water percolate into them.

The CHAIRMAN. Have you not bored at all?

Mr. DAVIDSON. You can not well bore into these boulders. You could do so with the proper machinery, but we have no such machinery. These wells on the mesas are at the same water level with this stream, so that it is one moving stream underground.

The CHAIRMAN. How wide?

Mr. DAVIDSON. A mile and a half in the case of the Rillito.

The CHAIRMAN. That is a vast amount of water?

Mr. DAVIDSON. Yes. The same conditions, I was going to say, are encountered in the Santa Cruz as far as my work extended on the same work near Tubac.

Senator REAGAN. Have you been successful in developing a considerable body of water in that way?

Mr. DAVIDSON. We commenced the work, but were stopped by floods. We carried the work so far as to establish the fact beyond a doubt. Of course our work is incomplete as yet. It is like building a house; you can not reap the benefit of the work at first.

The CHAIRMAN. Is it true that the streams run underground in this Territory generally?

Mr. DAVIDSON. Yes.

The CHAIRMAN. Is it true of the Gila also?

Mr. DAVIDSON. I am not sure about the Gila, but of all the waters I have had to do with there are more underneath the surface than on the surface.

Mr. GOODWIN. Fifteen years ago we commenced boring for an artesian well, some 200 or 300 yards from where we are now. We bored several hundred feet and encountered the same formation—sand and gravel. In regard to dikes for the catchment of water, in one of the places, as to which we will have the honor to report to you, the dikes of porphyry are about 30 feet apart. They jut up on the different sides of the stream.

STATEMENT OF E. L. WETMORE, OF TUCSON.

The CHAIRMAN. Have you been taking the record of the rain-fall?

Mr. WETMORE. Yes.

The CHAIRMAN. Will you please give us the particulars of it?

Mr. WETMORE. For the last twelve months the rain-fall, month by month, at Tucson is as follows:

Month.	Rain-fall.	Highest temperature.	Highest temperature.	Mean temperature.
1888.	*Inches.*	°	°	°
September	.10	103	.....	.....
October	.78	98	52	75
November	2.06	85	37	61
December	1.96	85	37	61
1889.				
January	1.74	77	30	54
February	1.06	77	29	53
March	1.98	81	44	63
April	.18	95	43	69
May	Trace.	96	44	70
June	.30	102	57	80
July	5.66	105	66	86
August	2.06	104	78	91

The rain-fall for the last twelve months has been 17.88 inches. I do not happen to have the lowest temperature for September, 1888.

The CHAIRMAN. Has there been any rain-gauging conducted on those mountains?

Mr. WETMORE. No. The rain-fall on the mountains is from two to three times as much as on the mesa.

The CHAIRMAN. Is there not more than that?

Mr. WETMORE. It may be more than that. There is no Signal Service report, except from Huachuca. At Pantana the rain-fall is about 20 inches.

The CHAIRMAN. Do you have any floods in this region?

Mr. WETMORE. Yes. The floods come in July, August, and September in the Santa Cruz and the Rillito, and permanent water runs during the months of January, February, and March on the Rillito in the winter from the snows of the Santa Catalina and the Rincons.

The CHAIRMAN. What time do you need to irrigate?

Mr. WETMORE. Principally in February and March and in July, August, and September. We have two planting seasons, winter and summer.

The CHAIRMAN. Do you raise two crops?

Mr. WETMORE. We raise two crops each year.

Senator REAGAN. What are your planting seasons?

Mr. WETMORE. One commences in September, October, and November, and from that time on until February for our wheat and grains. Our harvest season is in May and June. Then we plant again in summer for corn and such crops.

Senator REAGAN. What crops do you plant in July and August?

Mr. WETMORE. Corn, sugar-cane, and beans. We raise vegetables all the year round. There is not a month in the year that we do not have vegetables. Here [indicating some grasses] are some of the native grasses that grow in this Territory. These grow wild on the mesas during the rainy season, and only during that season. We have an

average of 4.22 inches of rain-fall from October to the 1st of April, and 6 inches of irrigation will produce a crop.

Senator REAGAN. In addition to that?

Mr. WETMORE. In addition to that. In the summer we have an average during the three months of July, August, and September of 6.23 inches of rain-fall. A crop can be produced by artificial irrigation with 7 inches.

The CHAIRMAN. You say you have floods in the summer?

Mr. WETMORE. Yes; the rain-fall is generally over in from fifteen minutes to half an hour, and then it runs off to the river.

The CHAIRMAN. The summer rains might be stored?

Mr. WETMORE. Yes.

STATEMENT OF BREWSTER CAMERON, OF TUCSON.

The CHAIRMAN. We shall be glad to hear you, Mr. Cameron, with regard to irrigation in this locality.

Mr. CAMERON. I desire to say a few words with regard to these grasses. There are a great number of grasses in this country. The most valuable of them all is the white grama. That grows on a soil that is usually a little gravelly. That soil enables it to get a good root. It is very fattening for horses and other stock. They will fatten quicker on this grass than on any other grass known. The only difficulty about the growing of grasses here is that we do not have enough rain to irrigate them. They grow rapidly during the rainy season, but it rains for such a small portion of the season that we do not have the water for them. On the mesas the condition of vegetation is such that it would require ages almost to get it out.

The cattle frequently throw their tongues around this grass and pull it up. It formerly grew in great quantities, but the cattle pulled it up. Large quantities of this grass have been eaten out, and this country rendered a desert. If you would take the whole Territory of Arizona to-day, just as it stands, it would require 50 acres of land to support one head of cattle on the open range. Some conservative people think it would take 100. I am sure it would take 50.

In the places where the rain-fall is more than usual you will find that the grasses hold on very well. In those portions of the country you can support one head of cattle—one animal—on anywhere from 7 to 12½ acres, whereas with alfalfa you could support two cows probably on 1 acre. They generally cut five crops of alfalfa here and also get seed for another crop.

The rain-fall here is very rapid, and then it runs off. The consequence is that it ought to be carefully preserved, and if preserved, this country would support an immense number of people and immense herds of stock.

My brother and I own a ranch 100 miles southeast of here, on the Santa Cruz River. Going around the way the stream runs it is probably 130 miles. There are different points along that river that I have observed where large reservoirs could be constructed which would reclaim hundreds of thousands of acres. There is one place three quarters of a mile wide and 4 feet deep—just the catchment area that it has on that land. There is an area there 15 miles wide and several miles long.

The CHAIRMAN. The reservoirs would have to be constructed, I suppose, very strongly.

Mr. CAMERON. Yes, or the storms would wash them away. But there

are places where reservoirs could be constructed strongly and well. We planted on our ranch some few years ago some peach trees, nectarines, and apricots, just from the seed. This summer the apricot trees bore very finely. The Mexicans also grow that class of fruit, and have done well with it. Fifty-one hundred feet above the sea, where our ranch house stands, we have planted olives, apricots, peaches, plums, quinces, and so-forth, English walnuts and almonds, all of which have done well. The first year I sub-irrigated, but the gentleman who made the irrigation ditch told me he made a bad selection of the material, and the fruit could get no water practically that year. The trees grew well, however, and as they did grow well in that high altitude, they would grow well here.

The CHAIRMAN. If you had Government surveys to designate the reservoir sites and set them aside, and estimate the cost of making reservoirs and ditches, are there many places in this country where private enterprise would utilize the water?

Mr. CAMERON. Yes, there are many. I will show you how that is. Some friends of mine called my attention to the fact that there was a great reservoir that could be built. I went East, and a gentleman from this city went with me. A gentleman to whom we appealed for a subscription subscribed $100,000, but on investigation it was found that it was not just what we had heard of it. I would be satisfied if the Government would make the surveys. I think the capital could be got to reclaim every acre of arid land in this country, if we had good surveys.

I am a member of the committee of this Territory to prepare a report for your committee. The engineer who was sent out to get information for submission to your committee came back and reported to us that there was a much better site out here than had been discovered before. Nobody has ever surveyed the place with a view of seeing what could be done in that respect. I think it is very important that the Government should survey these sites and reserve the land so that the minimum, not the maximum, may be taken and held by men who could crowd capital out, and prevent anybody from developing it. It is for that reason very important to have these surveys, so that some men can not come here for speculative purposes and keep back the development of this Territory for twenty-five or thirty years.

The CHAIRMAN. All the lands to be irrigated by these hydraulic works are withdrawn from sale, so that they can not be entered under the homestead law, or any other laws; but the President has power to open it to homesteads, which he would do, under the ordinary administration of law. Now what other laws do you wish changed besides the homestead law?

Mr. CAMERON. I was formerly receiver of the United States land office at this place, and ever since have been connected with many operations here. I have given much attention to this subject. I spoke to Major Powell in San Francisco about this matter, but he said that all the land within the basin of the river he had recommended to be absolutely withdrawn.

The CHAIRMAN. All that he designates are absolutely withdrawn.

Mr. CAMERON. All these mountains have lagunas in them, in which quantities of water could be stored, so that under the construction which the Commissioner of the General Land Office puts on that, every acre of land in this county is withdrawn.

(Mr. Cameron addressed the committee at some length in opposition to the repeal of the desert land act, asserting that such repeal would work great injury to Arizona.)

STATEMENT OF A. K. P. SAFFORD.

The CHAIRMAN. You have been governor of this Territory?

Mr. SAFFORD. Yes; from 1869 to 1877.

The CHAIRMAN. Are you familiar with the Territory?

Mr. SAFFORD. Yes.

The CHAIRMAN. Have you observed its capacity for irrigation?

Mr. SAFFORD. Yes.

The CHAIRMAN. The committee will be glad to hear anything that you may have to say with regard to that subject in its relations to this Territory.

Mr. SAFFORD. The largest river of this county is the Santa Cruz, which rises in Arizona, and comes into this county about 85 miles from here. It runs through a valley of as rich land as there is on the face of the globe. During the rainy seasons an immense quantity of water accumulates on the mountains, probably four or five times as much as in the valleys. There are frequent floods. By proper arrangements the water could be accumulated so as not only amply to irrigate all the lands in the valley above here, but it could be carried into the valley which we passed over.

The waters of the Santa Cruz sink, after passing about 9 miles from here north, and do not appear again until they reach Maricopa, near the railroad station. There the river comes out again. From the formation of the country you can tell where the water runs. Frequent experiments in sinking wells have shown the course of the water. When wells are sunk they sometimes find a running stream. I presume the water might be raised and do considerable irrigating, but if it were properly saved it could be gathered from the mountains. From here to the source of the river there is water enough, in my belief, to irrigate not only the valley above here, but tens of thousands of acres besides.

In addition to the Santa Cruz, there is the San Pedro River, which flows a distance of 150 miles and enters into the Gila. That flows through a very rich country, and, like the Santa Cruz, it is lined with mountains, where vast amounts of water can be accumulated and by which an immense area of country could be irrigated. The Rillito is another river that is susceptible of producing water enough to irrigate all the lands that you see here, if proper storage could be provided—the lands being all rich and excellent. You must have observed that it is also admirably calculated by nature for irrigation.

Another of the rivers is the Sonoita. That enters into the Santa Cruz some way up. That is a stream of considerable importance, and has a large water-shed. There is a valley, Babequivari, which is one of the richest in all the Territory. It is about 60 or 70 miles south. That, I believe, could be made cultivable by storage of water. In fact, I do not think there is any land in this county which could not be made cultivable if proper storage arrangements were made.

Senator REAGAN. How much would that aggregate?

Mr. SAFFORD. I suppose 2,000,000 acres. There is another feature I wish to call attention to. This valley here has been in cultivation for probably one hundred and fifty years, perhaps longer. We have no written history of the length of time that this valley has been cultivated. It had an old Spanish fort. That was one of the forts that the Spaniards made before the independence of Mexico was achieved. These lands were cultivated under the rule of Spain, and have undoubt-

edly been under cultivation for one hundred and fifty years. The soil is as rich to-day as it ever was, without any fertilizer whatever, except what it got from irrigation. Some of it now rents for $33.33 an acre.

I have had experience in agriculture in many States of the Union. I was born and raised on a farm, and after having had considerable experience in this Territory, and in other States of the Union, I can say that I know of no country so prolific as the Territory of Arizona. I lived for many years in Illinois, yet I know of soil nowhere that will produce crops from year to year for an entire number of years without fertilization, except this soil.

STATEMENT OF W. H. BARNES, UNITED STATES TERRITORIAL JUDGE.

The CHAIRMAN. We shall be glad to hear anything that you may desire to state with regard to irrigation, especially with reference to its application to this Territory.

Judge BARNES. I will say one word with reference to reservoirs. We have a town here of eight or ten thousand people, and there is not a well in it. Everybody must get water from our water system. The river here falls 18 to 24 feet to the mile. The water which you see here flowing comes from a redwood box 2 or 3 feet square, running underground for a quarter of a mile. It keeps along underground until it comes to the gravel, and you may put full pressure on all the faucets of this town, and that fact will make no appreciable difference in the supply of the water. That shows what is done with underground water.

It has been asked, "What is below this water?" We do not know. The more demands we make on the water the more water comes. A mile and a half below here a railroad company, with plenty of resources of money and machinery, sunk a well about 33 feet and encountered a force of water which they could not overcome. They put in a steam-pump, and finally put in two pumps, but could not overcome it. That well waters the machine-shops, the engines, the depot, this hotel that we are now sitting in, and a large part of the town besides. They could not go any further with all the means they could employ. They could not overcome the flow of the water that came at that depth. Of course, by means of a pipe and machinery for the purpose they could go on indefinitely, but with an open well they got all the water they wanted.

These mountains here have an immense rain-fall. The Government ought to ascertain what the fall of water is on these mountains. I believe that for 10 inches of water that falls in this valley 60 inches falls on the mountains. All over these mountains you will find rain-fall, but not a drop of that water has ever got to the river on the surface; it comes at such remote intervals.

STATEMENT OF ALEXANDER TRIPPEL, OF GLOBE, GILA COUNTY.

The CHAIRMAN. Have you anything to present with regard to irrigation in Gila County?

Mr. TRIPPEL. I have a short report which I am instructed to hand to you.

The CHAIRMAN. Do you wish to say anything in addition to that?

Mr. TRIPPEL. Yes. In order to save time I wish to make a brief statement of the contents of the report. Gila County is the central

county of Arizona and is surrounded by mountains. It has not any large irrigation schemes to present. It only desires me to say that one-half of the county is embraced in the Apache Reservation. The eastern half of the county is embraced in the San Carlos Reservation. The eastern part of our county has about 200,000 acres of arable land which is susceptible of irrigation by the San Carlos River and by a number of little mountain streams.

At the present time irrigation is carried on to a small extent under the direction of the War Department and the Indian Bureau. I should say that there are about 2,500 acres irrigated. This whole mass of land is reserved by the Government for about 4,000 Apache Indians. The western half of the county is entirely devoted to mining. It is mountainous country. It is made up of high and sometimes inaccessible mountains. The arable land of that western part would not aggregate more than 15,000 acres, although there is a good deal of mining land and mesa land. This 15,000 acres is in small patches along the creeks.

Irrigation is carried on to the extent of about 800 acres by small ditches, but there is no site that I believe could benefit Gila County in the least. There is, however, one great enterprise now proposed of which you may have been informed in Phœnix, which proposes to dam up the Salt River to the height of 200 feet right at the county line. This dam will float all the agricultural land of Gila County and would destroy all communication between South Gila and North Gila. It would be impossible to make any road across. It is a question which is probably novel in this irrigation scheme, but it will certainly loom up—whether one community can be benefited by such dams, to the ruin of other communities. In this case a lake would be formed of from 16 to 20 miles in length in the Salt River and 10 to 12 miles on Tonto Creek, so that the lake would cover all the farming land and go from mountain to mountain. The question involved in this matter is presented to you in the report for your consideration.

So far as underground water is concerned, I have noticed right around those mountains that the water-sheds are delivering any quantity of underground currents. They are inexhaustible. But we have no living streams outside of Salt River and some small streams.

Our people are very anxious regarding the act of Congress withdrawing all lands susceptible of irrigation. Of course while there are no sites which would warrant the turning of them into reservoirs for the benefit of Gila County, yet technically you could make such sites. They may not be economic and may not be needed, yet, in an engineering sense, sites could be made, and so all those lands that are now in the possession of homesteaders and others under the land laws are apt to be withdrawn from them. The uncertainty of this is so great that people begin to be in doubt whether they will do any more work or not. It would actually withdraw the lands which are irrigated by springs or by wells.

(This witness also addressed the committee in opposition to the repeal of the desert-land law.)

The report referred to by Mr. Trippel is as follows:

The undersigned, a committee appointed by the board of supervisors of Gila County, Ariz., and instructed to present to the committee such facts as may be of importance in the course of your investigations and relating to said county of Gila, respectfully submit the following, to wit:

Upon a careful examination of the subject, what, if any, measures and undertakings to irrigate and reclaim desert lands in Gila County not embraced in the White

Mountain Indian Reservation, could be submitted, we find that not sufficient arid land lying without the reservation limits is susceptible to irrigation to warrant Government work.

The most of the tillable land in Gila County is within the Indian Reservation in the San Carlos and Gila Valleys, and has been computed at 200,000 acres, or 300,000 acres for the whole reservation, a portion of which is in Graham County, and kept from the citizens and preserved exclusively for the questionable benefit of 3,000 or 4,000 Apache Indians.

The balance of agricultural and mesa lands susceptible of irrigation forms a narrow strip lying along the Salt River and Tonto Creek, not probably to exceed 12,000 acres in the aggregate. These two narrow valleys, each being about 16 miles in length and not over 2 in width, are surrounded on all sides by high and, except in a few certain places, inaccessible mountain ranges which extend north and south, east and west the entire length and breadth of that portion of the county not embraced within the Indian Reservation; a portion of the lands situate in these valleys are now irrigated by small ditches, and the configuration of the country is such that within the county and for its benefit no larger storage reservoirs would be warranted.

Another small acreage is in the valley of Pinal Creek, extending north from Globe and being about 10 miles in length by 1 in width, but which has no surface water, but could be irrigated by raising the water by means of underground dams.

Gila County is chiefly a mining country, mountainous, being situated within the great mountain ranges of central Arizona, with good grazing, but little agricultural land.

In this connection, we would respectfully call your attention to the late act of Congress withdrawing all entries of land under the homestead, timber, desert, and pre-emption or water-right acts, which, with a strict and literal construction, would prevent the further settlement of most, if not all, the arable land in our county, inasmuch as the act withdraws all land susceptible of irrigation by ditches or canals. The effect of such interpretations will cause a complete stagnation in the progress of this Territory, and especially Gila County, keeping in suspense every industry dependent on agriculture and forbidding immigration. The act does not discriminate but excludes every acre worth having from being entered, as long as the technical feasibility of the construction of a storage reservoir exists, without regard to whether a site for such reservoir may be hereafter found warranted or not. It is obvious that a law so forbidding to all progress, all increase of population, and so sweeping in its effect, will be destructive to the material prosperity of the Territory at large.

We would also respectfully submit the question, whether storage reservoirs or other water-works should be constructed for the benefit of one community or one county when, as a consequence, such an undertaking would be the destruction of another community or county. This question seems to us one of the greatest importance when justice to, and equal rights of, all citizens are considered.

We do not desire to submit to your honorable body a mere abstract question touching the right of eminent domain, but beg to present a case coming near to us when applied to Maricopa and Gila Counties.

Your committee has, no doubt, received from the authorities in Maricopa County the plan and official report of the county surveyor of the Salt River storage reservoir to be constructed in Gila County, intended to dam Salt River to a great height, and by which a very large tract of arid land in Maricopa County could be reclaimed. We do not wish to underrate the great importance and the inestimable benefit which would accrue to Maricopa County exclusively by the construction and operation of such water-works, but we are compelled to state that a corresponding damage, nay, almost an entire destruction of the integrity of Gila County, of its future material prosperity, of its communications between one part and the other, of any possibility of a railway through the county, which is so essential to its mining industries, and the flooding of nearly all its agricultural land would follow this undertaking, and we would respectfully ask whether the Government would sanction the principle of creating prosperity in one county upon the ruin of its neighbor.

The official report of the surveyor states that some 10 miles in the Tonto Valley and 16 miles up Salt River, together with a number of miles on Pinto Creek, all being in Gila County, would be flooded by means of this dam, and he estimates that about 6,140 acres of arable land, of which 902 are now cultivated, would be covered with water. This statement of the acreage now under cultivation is erroneous, as about 1,500 would be a more proper figure.

That report also fails to state that the whole flooding and entire damage would be in Gila County; that the creation of such a lake would virtually make ordinary communication between North and South Gila impossible; that the only feasible location of a north and south railroad to Globe, whose route has already been surveyed and 40 miles of track built, would be obliterated. The topographical features are such that not even a good wagon road through the mountains to the east of this lake,

except at an enormous expense, could be built, and even then the distance would be doubled.

The report further fails to mention the Verde River or any of its numerous tributaries as equally advantageous streams for water storage reservoirs, which, if examined, will be found to contain several sites for dams which would answer exactly the same purpose as the Salt River Dam, and could be constructed at probably less cost, and canals from which would irrigate precisely the same section of country, and whose construction and maintenance would interfere with or damage no one.

Another objection to this scheme of damming Salt River lies in the utter separation of the lands on the head of Cibuqu Creek from the mining regions surrounding and lying south of Globe. These lands contain large coal deposits, which at some not distant future day will be of great value and immense importance to the mining industries, especially of southern Arizona. This great lake, if constructed, will cut off all possible railway connection between these lands and Globe and the country lying south of Globe, except by road via Phœnix and Tucson, or to Deming, N. Mex., via Albuquerque, which are routes so circuitous that their construction would never be justified. We would also add that at the present time both southern and northern Gila rely exclusively upon the agricultural resources of the Tonto and Upper Salt River Valleys for all supplies of hay, grain, etc. This lake, flooding, as it will, the farming region of the county, leaves the remainder of the county practically without a farm, and from the mountainous character of the county and isolated as it is from adjoining farming sections, our people will be left without sufficient supplies of home agricultural products, and outside markets, owing to the great distance and almost insurmountable mountain roads, can offer nothing but at an enormous expense.

Under these circumstances the citizens of Gila County, to an unanimity, protest against such a wholesale destruction of a whole county, merely to benefit another adjoining county. Were it merely a matter of compensation for damage done, such may be adjusted, but the plan proposed conditions a material political disintegration of Gila County, affecting its communications and thereby destroying all hopes of future prosperity.

In presenting these facts as concisely as practicable, we feel satisfied that your honorable body will treat these grave questions with the consideration they merit, and that future Congressional legislation will duly recognize such important factors in the problem of an equitable limitation upon the schemes for the reclamation of large tracts of desert lands.

We remain, respectfully, your obedient servants,

ALEX. TRIPPEL,
Chairman.
J. H. HAMILL.
E. H. COOK.
F. T. POWERS.

Approved August 31, 1889.
[SEAL.]

PATRICK SHANLEY,
Chairman Board of Supervisors of Gila County, Ariz.

Attest:

CHAS. T. MARTIN,
Clerk of the Board of Supervisors, Gila County, Ariz.

STATEMENT OF C. H. MURRAY FIRST LIEUTENANT FOURTH CAVALRY, OF FORT LOWELL, NEAR TUCSON.

The CHAIRMAN. You have been stationed some time in Arizona?

Mr. MURRAY. I have, and studied somewhat the question of water supply.

The CHAIRMAN. Please give us your conclusions.

Mr. MURRAY. Wherever in Arizona a sure supply of water can be obtained for irrigation the element of chance is almost eliminated from agriculture. Unfortunately, except in very limited areas, it is impossible to obtain a regular supply without the aid of storage reservoirs. Streams that during the rainy months would water large areas, practically disappear in dry seasons. If the water wasted in the rainy months could be held for use during the dry, thousands of acres now arid could be

made very productive. This can be done by building a system of large storage reservoirs, since most of the mountain ranges of this Territory contain numerous cañons admirably adapted to the construction of such reservoirs.

In determining the water supply of a mountain range in Arizona, it is manifestly incorrect to base the estimate upon the charts of rain-fall. These charts are based upon statistics collected in towns, which, as a rule, are distant from the mountains, and for that reason are in centers of small precipitation. In the mountains, rain falls much oftener than in the towns (plains). Not only does it fall more frequently, but, usually, with a violence resembling cloud-bursts. If, in the mountains, statistics could be carefully kept for several years they would probably show that the annual rain-fall of Arizona has been greatly underestimated.

Adjourned.

The following papers and reports were read and ordered filed:

REPORT FROM COCHISE COUNTY,

CONTAINING STATEMENTS OF ITS GEOGRAPHICAL POSITION, CULTIVATED LANDS, CROPS RAISED, LANDS SUSCEPTIBLE OF CULTIVATION, MILES OF CANALS AND DITCHES, RAIN-FALL AND STATISTICS, RESERVOIR SITES, WATER-WAYS, AND WATER SHEDS.

[Prepared under the direction of the board of supervisors by its special committee.]

The following information gathered under the direction of the board of supervisors of the county of Cochise, Ariz., by Hon. M. A. Smith, Delegate in Congress, H. G. Howe, civil engineer, and Hon. T. J. White, a member of said board, is respectfully submitted for the consideration of your committee, with the earnest hope that it will receive the careful perusal which characterized the actions of the above-named gentlemen while studying the questions, a report of the results of which study, and after a very recent personal examination of the country mentioned, is herewith laid before you.

B. S. COFFMAN,
Chairman.
FREDK. CASTLE,
Clerk.

Cochise County is situated in the southeast corner of Arizona, is 83 by 84 miles square, and contains 6,972 square miles, an area five and one-third times greater than the State of Rhode Island, three and one-fourth times greater than Delaware, and one and one-half times greater than the State of Connecticut.

It is situated on the continental divide between the Pacific Ocean and the Gulf of Mexico. The highest altitude along the Southern Pacific Railroad from San Francisco to New Orleans, being at Dragoon Summit, is an altitude of 4,614 feet, the average altitude being about 3,800 feet above sea level. Cochise County is watered by the San Simon Creek on the east, which stream rises in New Mexico and runs northwesterly through Cochise and into Graham County, and empties into the Gila River at Solomonville. The Sulphur Spring Valley, running through the central portion of the county, heads in Graham County. The waters flow southerly into Mexico and form the headwaters of the Sonora River, which empties into the Gulf of California. The San Pedro River, near the westerly line of the county, rises in Mexico and flows northerly through the county and joins the Gila River a few miles below Dudleyville.

The San Simon Creek drains a water-shed of 36 miles in width and 40 miles in length, or an area of 144 square miles, which waters flow through Cochise County at

the northeasterly corner. The soil in many places being sandy, this stream runs under ground and comes to the surface at points only where the bed-rock comes to the surface, which points show an abundance of water.

This valley lies between the Pelloncillo range upon the northeast and the Chiricahua and Pinaleno ranges of mountains upon the west. Nearly if not quite all of this great valley could be irrigated, and valuable crops raised, could the waters flowing through it be but saved.

The Sulphur Spring Valley drains an area 30 miles in width by 90 miles in length, or an area of 2,700 square miles. This valley like the San Simon having a sandy soil, the waters flow under the surface, forming a broad underground stream a few feet below the surface throughout the greater portion of the valley. This valley lies between the Pinaleno, Chiricahuas, and Pedrogosa ranges upon the east, and the Mule, Dragoon, and Gallure Mountains upon the west. The vast majority of this great valley is also capable of raising anything, could the waters flowing through the same be saved.

The San Pedro River has a water-shed of 25 by 28 miles in Sonora, Mexico, and in Cochise County a water-shed of 25 miles in width by 80 miles in length, or a total, including Mexico, of 25 by 108 miles, or 2,700 square miles, of which 2,000 square miles are in Cochise County, which waters flow through Cochise County.

This valley, similar to the others above described, has a large underground current which comes to the surface only where the waters are raised by beds of clay or bed-rock coming near the surface. It is bounded upon the east by the Ajos, Mule, Dragoon, Limestone, and Gallura ranges of mountains and upon the west by the Catalina, Rincon, Whetstone, Mustang, Huachuca, and Cananea ranges of mountains. In this preliminary examination, the time being so short, it has been impossible to give the volume of water flowing in the different valleys; but from the many wells sunk along the bottom lands and upon the low table lands, and in the adjacent draws or flat washes leading into the valleys has demonstrated the fact that at no great depth from the surface there is an abundance of water. There is no known point in either of the above-mentioned valleys where the whole flow of waters comes to the surface. There have been no measurements taken to show the volume of these underground streams.

In addition to the streams described in this statement, there are many large springs, which do not feed permanent streams, whose waters properly used would be of great benefit in the irrigation of orchards and vineyards, as they are located in the mountains and higher table-lands. Many of them are now used by the settlers along the foot-hills for domestic purposes, some utilized by the laying of pipes to troughs for watering the cattle that graze along the table-lands and foot-hills, and others carried in ditches for the irrigation of orchards and vegetable gardens.

RAIN-FALL.

From reliable sources, taken for several years throughout what is termed the arid region of the United States, the following statistics are taken, showing that this portion of Arizona, and more especially Cochise County, has a greater rain-fall than many portions of California, Colorado, Montana, New Mexico, or Wyoming:

	Inches.		Inches.
Drum Barracks, Cal.	8.74	Fort D. A. Russell, Wyo.	14.09
Fort Yuma, Cal.	3.91	Fort F. Steele, Wyo.	15.38
San Diego, Cal.	9.31	Santa Fé, N. Mex.	14.91
Monterey, Cal.	15.71	Albuquerque, N. Mex.	8.11
Fort Garland, Colo.	14.86	Fort Filmore, N. Mex.	8.42
Denver, Colo.	13.77	Fort Selden, N. Mex.	8.40
Fort Lyon, Colo.	12.56	Fort Craig, N. Mex.	11.06
Fort Snow, Mont.	6.95	Fort Bayard, N. Mex.	14.32
Fort Benton, Mont.	13.26	Fort Huachuca, Ariz.	15.60
Fort Sanders, Wyo.	11.46	Camp Grant, Ariz.	15.08
Fort Laramie, Wyo.	14.45	Camp Bowie, Ariz.	15.26

From the above list it will be seen that this county has a larger rain-fall than most of the above named stations, an average rain-fall of over 15 inches, of which nearly 50 per cent. falls during the summer and early in the fall, the next largest percentage being in the fall and winter, the smallest being in the spring. Frosts are rare, and in the valleys all the precipitation comes in the form of rain. As the limit of successful agriculture has from a great many observations been set at 20 inches, it will be seen that this county lacks about one-fourth the water to successfully carry on agriculture without irrigation, which per cent. must be provided for by some system of storage reservoirs or underground irrigation for vineyards and orchards.

RESERVOIR SITES.

In examining the San Pedro Valley there are but two points where reservoirs can be built to an advantage:

First. On the lower portion of the valley, at a point where the foot-hills come close together, with solid rock upon each side and bottom. This is known as the Nigger Ben place, and is about 15 miles below or north of the town of Benson, where a dam 350 feet in length and 40 feet high will overflow an area of a mile square and average 10 feet deep, or a storage capacity of 278,784,000 cubic feet. The area of bottom land and low table-land that could be irrigated by the construction of this dam would be in Cochise County over 3,000.

The second reservoir site on the valley, 1¼ miles above Charleston and 26 miles above Benson, where the foot-hills come down to the river forming solid rock banks for over a hundred feet high, where a dam 60 feet in height and 400 feet long would store over 300,000,000 cubic feet of water.

There are several places along this valley where there are broad stretches of almost level bottom-lands where underground dams (that is, trenches at right angles to the valley cut to bed rock or clay and filled with concrete) could be placed, that would raise the underground current to such a point that thousands of acres could be brought under cultivation without irrigation and save the expense of ditches and the great loss by evaporation.

Storage.—With this system of underground storage reservoirs, ditches from these dams can be taken out much higher up on the bottom lands, thus bringing under cultivation hundreds of acres that can not now be irrigated from the main channel of the river.

This system of underground damming would only expose for evaporation the narrow channel of the river, which would be but a small percentage above that of the present stream.

There are several points along the San Pedro River upon the west side where stronger reservoirs could be built.

One is at what is known as Page's Cañon, which drains from the southerly portion of Happy Valley, where there is running water the entire year. At this point the cañon is narrow, and walls solid. A dam 160 feet in length and 75 feet high will here store over 200,000,000 cubic feet of water and bring under cultivation over 20,000 acres that can not now be cultivated, owing to the sinking of the water below the cañon.

There are large flats to the east and west of Benson, where the soil is first-class, and could be irrigated by storage reservoirs built in the V-shaped washes that drain a vast portion of the country lying north of the Whetstones and west of the Dragoons Mountain ranges, which washes, or small cañons, carry large bodies of water during the rainy season. A series of dams, one above another, would store an immense body of water, enough to irrigate hundreds of acres of land, but the evaporation would be so great that but a small part of the water would be available for the early summer months when irrigation is needed most. If the water stored were to be used immediately after the rainy season during the early fall months this system of storage would warrant the expense, but the spring and winter rain-fall being so small there would be but little water left for use when needed most for growing crops.

This portion of the county gives the best indication, from its surroundings, for the sinking of artesian wells, with which these large areas could be irrigated with but a very small loss from evaporation.

The mountain ranges, especially the Chiricahua and Huachucas show several points where storage reservoirs could be built, but the amount stored would be so small compared with the expense of the dams, and the feeders to supply the reservoirs so small, that the quantity stored would be exhausted before the cultivated crops would be matured.

MILES OF CANALS AND DITCHES.

In the San Simon Valley there has up to the present date been but little done in the way of irrigation by taking out water in ditches; a few have been taken out for the raising of alfalfa—about 2 miles of ditch.

In the Sulphur Spring Valley there have been not over 4 miles of ditches taken out, most of which is used for small gardens.

Some portions of the San Pedro Valley show old ruins, and the remains of pottery and of old ditches are yet to be seen. They show that this valley was inhabited a long time ago. The valley is now quite thickly settled, there not being a mile of the bottom lands but what has been settled upon, and there is now over 45 miles of main ditches and laterals now in use along the river bottom.

All of the main ditches are supplied from the main stream by building dams in the river at the most available points, all of the dams built to date being simply tempo-

rary dams that at almost every freshet are carried away and have to be rebuilt sometimes two or three times a year.

The dams are usually built of brush and earth, with some stone, if stone can be had; some are built by filling sacks with sand and laying them across the stream, thus throwing the water from the main channel to the head of the irrigating ditch.

KIND OF CROPS RAISED.

The soil along the San Pedro River produces all the different varieties of vegetation, cereals, grasses, fruits, and vegetables known to a semi-tropic zone. Of cereals there are raised corn, wheat, oats, and barley; of grasses, alfalfa, blue-grass, timothy, etc. Of fruits the following are being produced: Peaches, cherries, pears, apples, quinces, apricots, nectarines, figs, plums, grapes, strawberries, and all the small fruits, and it is noticed that the fruits have a finer flavor than many of the fruits raised in the lower altitudes of Arizona.

The foot hills on each side of the mountains are covered with nutritious grasses most of the year, which render it valuable for grazing purposes. San Simon Valley, as well as Sulphur Spring Valley, is covered with luxuriant grass growth, which makes them the finest cattle-ranges in Arizona. In Sulphur Spring Valley there are no running streams, but water is abundant and near the surface, and in some places gives the appearance of wet lands.

LANDS IN CULTIVATION.

In the San Simon Valley there are not to exceed 300 acres under cultivation; in the Sulphur Spring Valley and adjacent foot hills there are about 2,000 acres under cultivation; in the San Pedro Valley and adjacent table lands there are under cultivation about 6,000 acres.

LANDS SUSCEPTIBLE OF CULTIVATION.

There are in San Simon Valley, 60,000 acres; in Sulphur Spring Valley, 200,000 cres; San Pedro River Valley, 50,000 acres.

All of which is submitted.

STATEMENT OF F. W. OURY, C. E., OF TUCSON.

[Referred by Mr. Goodwin.]

To the Committee on Data and Statistics for Pima County:

I have the honor to submit the results of my examination of the sites for dams to which you have sent me. Accompanying this are maps and diagrams to which I respectfully refer for the better understanding of this report.

Location.—The sites for the proposed dams are located on the water-course commonly known as the Pantano Wash. Dam No. 1 is situated at the junction of the Cienega and Davidson's cañon, about 23 miles southeast of the city of Tucson, where still stand the ruins of the Cienega station on the old overland stage route. About 5 miles down the cañon, where the Southern Pacific Railroad track leaves the edge of the wash to go on to the mesa, is the site for Dam No. 2. Dam No. 3 is still farther down, about 2 miles from the preceding one.

Water supply.—Water runs throughout the year as far down as Dam No. 2, but in such small quantities as not to be a very important factor as a source of supply. Hence, it must depend on the freshets which come along this water-course, caused by the rain-fall over the country which it drains and which occur during the rainy seasons, summer and winter.

Drainage.—The Pantano Wash rises in a range of low mountains about 50 miles southeast of Tucson, known as the "Canelas," and runs, with innumerable bends and crooks, in a northwesterly direction, until it empties, near Fort Lowell, into the Rillito Creek; thence westerly until it reaches the Santa Cruz River. It thus drains a portion of all the mountains in eastern and southeastern Pima County, with the exception of the Patagonias. We shall refer, however, only to that portion of the water-shed, the water from which flows into the Pantano Wash above the points selected as sites for dams.

It will be seen from the accompanying map that the western slopes of the Whetstones and Mustangs, the eastern portion of the Santa Ritas, the southwestern slopes of the Rincons, all of the Empire Mountains (altogether about 60 miles of mountain ranges), besides a vast area of high rolling lands, would contribute their surplus of rain-fall.

A cursory glance at the eroded condition of the banks of this stream will convince a person at once that vast bodies of water run down this cañon. Great dykes of hard rock have literally been cut through by the water, large cotton-wood trees have been uprooted and carried down the stream, railroad ties, bridge timbers, iron bolts, and even steel rails are to be found miles away from where they were originally placed. So great was the damage done to the track of the Southern Pacific Railroad yearly that the company had, for the sake of economy, at great expense to elevate its road beyond the reach of the waters from this wash. At a point where the cañon is over 200 feet wide water marks from a recent freshet still remain which are 20 feet above the lowest point of the channel. These are conclusive proofs of the fact that enormous quantities of waters flow to waste annually, whereas if it could be properly stored in a system of reservoirs it would be sufficient to irrigate thousands of acres of land which are now worthless, and which would forever remain so unless reclaimed by the waters from this cañon, because the topography of the country would not permit its being brought from any other stream or wash.

Dams.—No. 1.—At this point a large dyke of hard volcanic rock crops out on the left bank, continues on the surface until it reaches the bed of the creek, then sinks beneath the sandy bottom, to appear again on the right bank of the main channel. At the extreme right end of the dam is also to be found solid rock, so that this dam, if constructed, would have three natural and solid abutments upon which to rest, namely, one on each end and one in the middle. Besides, the indications are such that bedrock can not be far distant from the surface of the sand. Therefore at this point a very strong dam could easily be built and, as we shall see afterwards, at a comparatively moderate cost.

The total length of this dam is 1,052 feet, and its greatest height is 67.5 feet. Its heights at different points are as follows: Commencing from the left, the first 200 feet in length, would average 20 feet, the following 50 feet would be about 45 feet high, the next 200 feet, being the main channel of the wash, would reach a height of 67 feet, while the remaining 600 feet would average no more than 35 feet.

In addition to the main dam, a small one would have to be built. Its length is 150 feet, and its average height through that distance would be about 6 feet.

Above the site of dam No. 1, along the Cienega Cañon and for a short distance up Davidson's Cañon, the waters have worn through the sediment which they had previously deposited, which averages 150 feet in width and 15 feet in depth. The fall of the Cienega Cañon in this locality is about 40 feet per mile; that of Davidson's Cañon about 50 feet per mile. The dam, then, being only about 34 feet above the broad basin of the cañons, would back the water along the Cienega Cañon for about 4,400 feet, and up the Davidson Cañon for about 3,700 feet. The basin of the former cañon averages about 2,000 feet in width; that of the latter about 800 feet. Hence, to speak generally, this dam would create two rectangular sheets of water, one 4,400 by 2,000, and the other 3,700 by 800, or, more accurately, as found by survey, the water would cover in the Cienega an area of 9,160,073 square feet, or 210.3 acres to an average depth of 26.47 feet, taking into account the deep channel already spoken of. In the Davidson Cañon a lake would be formed containing an area of 2,784,340 square feet—63.92 acres—having an averege depth of 20.50 feet.

Therefore the capacity of this reservoir would be equal to 299,580,795 cubic feet, or 2,241,019,947 gallons; in other words, it would take a ditch with an average width of 8 feet and an average depth of 2 feet, running at the average velocity of 35.6 feet per minute, 365 days to empty the contents of this reservoir, it having been once filled and no more water coming into it during the time that it is being emptied. Again, this amount of water if spread out over a level plain would cover 82,529 acres, or 515 one quarter sections, 1 inch deep. It has been mentioned that the waters have deposited sediment in the basins of both the Cienega and Davidson's Cañon; in fact, the soil in these basins is nothing more than this sedimentary deposit. There are places where the water has cut through it for a depth of over 20 feet, and it still continues down some feet deeper. This, too, must have been deposited within a comparatively recent period, since in the Davidson Cañon, at a depth of over 10 feet, where the water has worn down to the solid rock, there are to be found Indian mortars, familiar to all Arizonans. They are holes cut in the rock for the purpose of grinding acorns and mesquite beans. From this can be formed an idea of the amount of mud that the water carries.

Here, then, would be a serious difficulty which would have to be overcome. How could the débris and sediment be handled that would inevitably be deposited by the water if its velocity were checked by a dam? It could not be done by any system of sluice-gates; since now that the stream is unobstructed the water has only sluiced out a channel of an average width of 150 feet and something more than a mile long. The most that could possibly be done by sluice-gates would not be half this amount, and that portion of the area which would not come within reach of the strong currents caused by the gates would undoubtedly fill up. In this case at least two-thirds of the area of the reservoir could not be acted upon by the said currents; so

that the only way to get rid of this débris would be by dredging, an operation which, as every one knows, is quite an expensive one. Next is to be noted that the track of the Southern Pacific Railroad, which runs along the north bank of the wash, crosses the site of this dam at a point which would be 30 feet below the top. Now, as the grade of the road up this cañon is about 40 feet per mile, the waters from the reservoir would cover three-fourths of a mile of track, besides rendering it useless for some distance on both sides of the dam.

If the dam were built so as not to interfere with the railroad its height would have to be reduced at least 35 feet, and this in turn would diminish the capacity of the reservoir to about one-third. Or if in order to prevent this interference it should be proposed to dam Davidson's Cañon alone, its cost would nearly equal the one above referred to and have only one-fifth the capacity.

Dam No. 2.—This dam, too, would have solid abutments upon which to rest, and although bed-rock is not seen upon the surface in the bed of the stream it is evident that it is only covered by the sand. The span, besides, being so short, this dam could be made not only the strongest, but the least expensive. It will be seen from the diagrams that its total length is 418 feet and its greatest height is 43.43 feet, and as the banks on both sides are so steep the dam will average a height of 40 feet through its entire length. The fall of the wash at this point is something more than 40 feet per mile; hence, the dam would back the water up stream not quite 1 mile. The basin also is comparatively narrow, and therefore would not make a very large reservoir. According to surveys the water would cover an area of 2,923,658 square feet, or 67.12 acres, to an average depth of 22.37 feet. Therefore its capacity would be 65,391,298 cubic feet, or only about one-fourth as much water as that caught by Dam No. 1. This is a small quantity of water, but it will be seen hereafter how this dam is an indispensable accompaniment to the success of the large dam, No. 3.

Dam No. 3.—The banks of the Pantano Wash after leaving the point for Dam No. 2 are of a gravelly nature, more or less strongly cemented together. At places where the current of the main channel cuts into the sides a hard conglomerate, somewhat of the nature of "caliche", is exposed. At no point, however, do we find croppings of solid rock. Dam No. 3 would not have the natural rock supports of dams Nos. 1 and 2. It is doubtful, too, whether bed-rock would be reached in the construction of this dam, hence we can anticipate a loss by seepage underground. However, if a puddle wall of clay or some other good material were built through the sand until it reaches the conglomerate, to which reference has been made, and which is quite impermeable to water, this loss could be, if not altogether stopped, at least very greatly diminished. The red sandy clay from which the Indians make their "ollas" and which abounds in the mesas in the vicinity, would be a most excellent material with which to built such a puddle wall.

The total length of this dam is 2,640 feet, or exactly one-half mile, and its greatest height is 73.96 feet. For 600 feet it would have an average height of about 50 feet, and for the remaining distance its height would average nearly 70 feet. It would back the water up the cañon a distance of 7,500 feet, the average width of the basin being about 3,000 feet. As found by our surveys, this reservoir would extend over an area of 22,400,017 square feet, or 514.23 acres, having an average depth of 33.53 feet; that is, it would contain 752,169,384.8 cubic feet of water. It will be noted that this amount is over twice as much as that which the other two reservoirs would hold. It would take one year to discharge this amount of water through a ditch 12 feet wide by 4 feet deep and running at a velocity of 29.42 feet per minute; or if this quantity of water were spread 6 inches deep over a level plain it would cover 34,484.26 acres, or 53.88 square miles, that is to say, it would flood a strip of level land 25 miles long by 2⅛ miles wide, 6 inches deep.

It has already been said that enormous torrents of water, running at an almost incredible velocity, and carrying destruction in their course, pass down this wash. Therefore, if the velocity of the water is not checked in some manner, a dam as long as this one would be at a disadvantage against this element, and a most ponderous structure would have to be built in order to resist the rush of water. In fact, since we have already seen that it would not have a natural rock foundation upon which to rest, it is even doubtful if it could be done at all. Here then is the necessity of Dam No. 2 in connection with this one. It is a well-known law of hydraulics that if water passes from a narrow channel into a broader one, or into a large body of still water, its velocity is checked in proportion to the difference in the cross sections of the channels, and consequently its energy diminished. Dam No. 2 may be easily built strong enough to resist the most powerful current. Hence it could be used to check the velocity of the water, and when it reached Dam No. 3 its force would be greatly reduced. Furthermore, it must be remembered that when reservoir No. 3 is once filled its waters would reach within 1,000 feet of Dam No. 2. Here again the current would receive an additional check by impact, so that by the time it reached the dam its velocity would be practically *nil*. Therefore the strength of this

dam need not be such as to resist the force of any very great rush of water, but merely a little more than sufficient to sustain the quiet pressure.

The two dams can be made to act together in the following manner: The water charged with débris and sediment would come into No. 2, where its velocity would be diminished; consequently, the heavy material, such as gravel, sand, and the coarser particles of mud, would at once be dropped. Thus, none of these substances would flow over, and only the lighter sediment in suspense would reach Dam No. 3; in other words, the reservoir of Dam No. 2 would act in the capacity of a large settling pond for Dam No. 3.

Even after the water deposits its heavier burden it would contain a considerable quantity of fine sediment, the disposal of which would have to be provided for. This could easily be done by a proper distribution of sluice-gates along the bottom of Dam No. 3. It is so long that by making openings at proper intervals through which water can escape the currents so caused would be sufficient to scour the entire basin of the reservoir. This sluicing could be done whenever there should be a surplus of water, and this would happen once a year at least, that is, during the summer rains.

It will be observed that this arrangement renders it impossible to dispose of the accumulation in Dam No. 2 by sluicing. In no case, however, could this method be employed with any degree of success in this dam, it being too short to admit of the distribution of a sufficient number of gates. The only practicable way then would be by dredging, and since the area of this reservoir is comparatively small this could be done to advantage.

Building material.—A short distance above Dam No. 2, and in fact all along the banks of the wash, are to be found large deposits of a rock from which could be made the finest quality of lime. Granite and a compact species of limestone, very well adapted for building purposes, abound in the vicinity. Sand and gravel can be obtained from the bed of the stream. Hence, lime-kilns and quarries could be established, near at hand, which would supply at a moderate cost all the materials requisite in the building of masonry structures.

Evaporation.—In no portion of the United States, perhaps, is evaporation so great as it is in Arizona. During the five warmer months it will probably reach three-tenths of an inch per day, and through the remaining cooler season no more than one-tenth of an inch, thus averaging yearly one-sixth of an inch per day; in other words, it would amount to about 5 feet over the entire surface yearly.

It must be remembered, however, that summer, during which time evaporation is very much greater than in winter, is precisely the period when freshets are more frequent. The summer rains commence in the latter part of June and end in September; the winter rains commence in December and last until April. These, too, produce freshets, and it is to be noted that since it is the product of the gradually melting snows the water does not come in such large bodies, nor does it carry such a great quantity of sediment in suspense. Hence, we see that the only months through which the reservoirs would be without receiving occasional supplies of water are October, November, April, May, and a portion of June, months during which Arizona enjoys her proverbially mild and delightful weather, and in consequence of which the evaporation would be comparatively small.

Besides, we have already said that there is running water through the entire year as far down as Dam No. 2. This is a stream 4 feet wide, 3 inches deep, and running at the average rate of 1 mile per hour. Consequently it carries 126,720 cubic feet per day, or 45,252,800 cubic feet per year; in other words, this amount would cover the whole surface of reservoir No. 3, 2.02 feet deep. Therefore, this stream alone would supply enough water to make up for nearly one-half the yearly evaporation from the reservoir.

Lands.—The slope of the wash, as has been said, is about 40 feet per mile; that of the adjoining land is twice this. Hence, the mesa being 73.96 feet higher than the lowest point of Dam No. 3, in a little less than a mile the water can be brought on the mesa lands for irrigating purposes. The dotted line on the map showing catchment area, represents points on a level with the bottom of reservoir No. 3; that is to say, it is the boundary line, north of which the lands can be irrigated by water from this reservoir. Thus we see that the strip of lands bounded by the Santa Cruz River on the west and the Pantano Wash on the east, besides the bottom lands of the Santa Cruz River for 12 miles above Tucson, could be placed under its waters. The country embraced between the Santa Cruz River and the Pantano Wash is composed of what is known as mesa lands. On these plains grasses and weeds of many species flourish with only the moisture derived from the small amount of rain that falls on them, showing that the soil, a red, sandy loam, is very rich, and, it being compact as well as fertile, requires less water than any other to raise a crop. A few of our enterprising citizens have demonstrated, by great labor, what can be done with these lands, if only water could be obtained.

OTHER POINTS EXAMINED.

Madera Cañon.—This cañon heads in the highest point of the Santa Rita Mountains and drains the northern slopes of the west half of these mountains. Until it empties into the Santa Cruz River, where it spreads out into a wide flat plain, it is a narrow gorge with a great fall. Consequently no point is to be found in this cañon at which a dam, if constructed, would create a large reservoir. Adjoining this wash is a mesa, upon which this stream could be thrown, but as I found its slope to be about 150 feet per mile, and the nearest distance that its banks came together to be about three-fourths of a mile, I regard it impossible to construct a reservoir for irrigating purposes.

Sabino Cañon.—This cañon is much the same in character as the preceding one. Just before it empties into the Rillito Creek its basin becomes broad, but its banks are so low and so widely separated that it would be impracticable to dam it with the view of holding water for irrigation. Farther up, when it gets into the mountains, it becomes very narrow and has a steep slope. It is nothing more than a mountain gorge, such as are to be found in all high mountains, and which every one knows it is impossible to dam so as to catch any great quantities of water.

Puertisitos.—This is situated in the Altar Valley 9 miles north of the boundary line between Arizona and Mexico. The slope of this valley is such that a dam, the highest point of which would be 41.68 feet, and whose total length would be only 920 feet, would back the water up the valley nearly 1¼ miles, the average width of the basin being about three-fourths of a mile. It would cover an area of more than 800 acres to an average depth of about 15 feet.

The catchment area of this dam, however, would consist only of about 8 miles of the lowest portion of the Baboquivari range of mountains, together with about 25 square miles of rolling mesas, so that it can readily be seen that water enough does not come down this portion of the valley to fill the reservoir which this dam would create. Besides we have been informed by Mr. Aguirre, who has for many years resided about 2 miles above this point, that a natural lake, upon which he has located, and which covers about 300 acres with water to an average depth of about 3 feet, catches all the water that runs down the main valley. Once only does this gentleman remember that this lake has overflown, and that, too, over a very small section. Therefore this site is unsuitable for a dam.

STATEMENT OF LEONARD WOOD, FIRST LIEUTENANT AND ASSISTANT SURGEON, OF FORT McDOWELL.

Referring to proposed surveys for the purpose of irrigation of desert land in this and other sections of the West, I have the honor to forward the following notes, made mostly from memory, relative to possibilities in the way of storage of water and irrigation in this particular section:

The Santa Cruz River rises in Sonora, a few miles south of the line, about 35 miles south of Fort Huachuca, Ariz., and crosses the boundary near the town of Calobasas. From this point it flows nearly northwest to the town of Tucson, passing through a rich valley, in which are seen the remains of settlements and systems of irrigation constructed by an unknown people, and also the ruins of settlements founded by the Jesuits and Dominicans in the sixteenth century. This stream, like many others in this arid region, sinks in places, rising again where the bed-rock or impenetrable clay, forming the true bed of the stream, approaches the surface. During the entire year there is in many places a constant surface-flow, and during the rainy season a constant surface-flow throughout the entire extent of this portion of the stream. Attempts on a comparatively small scale have been made at or near Tucson, which have demonstrated the existence of a large subterranean stream and the possibility of bringing it to the surface by means of a dam founded on the bed-rock or strata forming the true bed of the stream. It is believed that a suitable dam at such a point as could be selected would enable enough water to be collected and stored during the rainy months, in addition to that brought to the surface, to irrigate a large portion of this valley. The soil is of excellent quality and of great depth near the stream; at a distance, where the bottom land slopes upward, the soil becomes lighter, but is suitable for fruit and vegetables.

In the neighborhood of the head of the Santa Cruz, and separated from it by a low divide, is the San Pedro River, which flows through a country similar to that bordering on the Santa Cruz. This stream is a surface stream throughout that portion of its extent with which I am familiar, and could, I believe, be stored up in sufficient amount to irrigate many thousand acres of land. Several prosperous Mormon and other settlements are already established on its banks. Its general direction is the

same as that of the Santa Cruz. The volume of water carried is much larger and more constant. Both streams empty into the Gila River.

Between these two streams are the Huachuca Mountains, the western portion being situated on the Huachuca military reservation. All the cañons in these mountains have streams fed by springs higher up the range. These springs are constant, and during the winter and rainy season the flow of water is large and forms good sized streams, which run out on to the flats and become lost. The amount of water coming from each of these cañons would, if stored up, irrigate several thousand acres of land. The cañons are narrow and deep and favorable for the construction of dams.

Leaving this section of Arizona in the vicinity of Huachuca Mountains and Tucson, and considering that portion near Phœnix, including a portion of the Salt and Verde Rivers, I shall refer first to the Salt River, and second to the Verde.

The Salt River is formed by the White and Black Rivers, rising in the White Mountains in the neighborhood of Fort Apache, Ariz., and for the greater portion of the course flows through cañons and narrow valleys until it reaches the western end of the Superstition Mountains, about 12 miles southeast of this Post (McDowell). Here it runs out into the eastern portion of that vast tract of country, more or less level, which stretches off toward the Colorado River and upper portion of the Gulf of California. Along the banks of this river, throughout its extent, are evidences of a dense population existing at some former time; also traces of great systems of irrigation, etc. Around and about Phœnix there are at the present time many thousand acres of land under irrigation, supplied by a system of canals taking water from this river. At present, even in the present comparatively undeveloped condition of this extensive section of country, the want of sufficient water is beginning to be felt, and unless some means are taken to store up a portion of the immense volume of water which flows down this stream in winter the limit of development must soon be reached. The amount of water carried by this river during the winter months is very great, rendering it unfordable for weeks at a time, and in places it is half a mile wide with a maximum depth of 10 feet or more. For 25 miles previous to its emergence from the Superstition Mountains it passes through a cañon formed by these mountains and the Mazattelle Mountains. This cañon is of great depth in many places, and in others it widens out and has opening into it numerous large cañons extending for miles up into the mountains on either side.

There are several places where the cañon comes down between mountains of considerable height which border on the river, making a comparatively narrow passage of from 300 to 500 yards in width, where a dam could be constructed which would cause a backing up of the water in the cañon and an overflow into adjoining depressions and cañons joining the river cañon at right angles, thus storing up an immense body of water for use during the dry season when the flow in the river is at a minimum.

The Verde, rising in the Francisco Mountains, joins the Salt River at a point about 6 miles below the point of exit of the latter river from the Superstition Mountains, and its waters go to form a portion of the supply used in irrigation about Phœnix and the adjoining sections. This river passes through the center of the Fort McDowell Reservation, and a small portion of its water is used to irrigate the land under cultivation thereon.

At a point 12 miles north of the post it emerges from a long, narrow, and deep cañon with features somewhat similar to those of the Salt River Cañon. It presents as favorable places for the construction of dams, etc. Like the Salt River, it carries an immense volume of water during the winter season, which, if only partially stored up, would irrigate an immense area. The country which would be irrigated by a system of this kind is one of the richest in soil of any in the United States, and with water its productive capacity would be almost unlimited.

Snow never falls and frost is very rare.

The Gila River runs through this section of country about 20 miles south of the Salt River. The two rivers join a short distance below Phœnix and flow on to the Colorado, the combined streams being called the Gila River.

STATEMENT OF W. A. GLASSFORD, SECOND LIEUTENANT, SIGNAL OFFICER, SIGNAL CORPS, U. S. ARMY, OF PRESCOTT.

RAIN-FALL IN ARIZONA, AND ITS EFFECT ON IRRIGATION AND WATER STORAGE, WITH DESCRIPTION OF SOME FAVORABLE POINTS FOR STORAGE RESERVOIRS.

General features of Arizona.—No portion of the Union probably presents such favorable conditions for the artificial catchment of water for agricultural and other purposes as does Arizona. In its great area, nearly double that of the six New England states, are presented physical features peculiarly adapted to the construction and maintenance of an immense system of irrigation based on the storage of water by artificial reservoirs, and the supply of which it will be the endeavor of the writer to show is abundantly provided for by rain-fall.

Were it possible to obtain a birds-eye view of the Territory, the observer would see spread out before him an area equaling Italy in size, consisting of a series of mountainous plateaus, ranging in height from 7,000 feet in the northern part of the Territory, to a few hundred feet in the southwestern portion. Of these plateaus those of the north will be found interspersed with mountain chains and deep cañons. In some places volcanic cones rise over 5,000 feet above the plateaus, while cañon gorges are cut as deep below. To these characteristics the plateaus of the southwestern portion of Arizona present strong contrasts, consisting as they do of level valleys, mesa or table lands, gradually sloping off towards the Gulf of California. Some of these are basins of what have been, at comparatively recent periods, immense inland seas. In places the loss of altitude is so rapid that immense cañons have been cut by erosion through the mountain chains and plateaus, and immense basins have been formed along the water-sheds of all the permanent streams.

These cañons and basins are of great depth and area, and present unrivaled facilities for the construction of a system of artificial reservoirs similar to that established by the British Government in India, where the Himilayas present much the same characteristic features. The streams, which in the north flow through cañons whose precipitous sides tower thousands of feet above the surface of the water, as they reach the southern mesas roll sluggishly along, with barely sufficient fall to prevent their sinking in the sand.

It is in the valleys along the latter portions of the rivers of Arizona that are to be found rich alluvial lands unequaled in fertility and productiveness.

The areas of these lands in Arizona are variously estimated from 6,000,000 to 10,000,000 acres, or an area surpassing all of Massachusetts, Connecticut, and Rhode Island, or Belgium, and nearly equaling Switzerland. The vastness of these areas can scarcely be realized from the mere mention of the figures, but their extent can be appreciated when it is remembered that the entire area of such land susceptible of reclamation on the Rhone in southern France is less than 400,000 acres; Spain does not equal this, while the famous Deltaic provinces of lower Egypt possess but about three times this area, and India, the oldest settled of all lands, has but about five times as much as France under cultivation through irrigation.

Irrigation and water storage in Arizona.—The almost level and uniform surface of these lands in Arizona makes this reclamation by diversion of water upon them easy when the water is obtainable. Many streams are now used for irrigation by diverting the water by canals. The lands thus reclaimed are close along the banks of streams, where the diversion is accomplished by gravity. So prolific and various are the productions of the land already reclaimed that canals and ditches have increased so as to go far to exhaust the available permanent flowing streams. This is especially observed when the stage of supplying streams is at the minimum, occurring during years of scanty rain-fall.

The utilization of water for arable land has forced in some places an approach to the exhaustion of the water supply that can be depended upon during years of extreme drought, at least gone far to alarm the rights held by prior appropriators. Above the existing canals is more land, and in some localities vast quantities, that only want the water brought upon it. This conducting of water to higher levels involves in most cases the necessity of either very long canals, because taken from a point higher up the stream, or storage dams by which a higher level for the exercise of gravity is obtained without increasing the length of canal. We thus see that an increase of the amount of water by storage projects is favored by two considerations: First, to widen the area of land possible to be reclaimed; and, second, to secure sufficient water during seasons of drought. Such storage being necessary to the general welfare, the question of the practicability of impounding water naturally arises.

The solution of this question is found primarily in an accurate determination of the depth of the annual rain-fall, with both the maximum and the minimum that may be expected in the district under consideration; also any peculiarities of its distribution.

This preliminary investigation is obviously that of the meteorologist and belongs to the signal service, a task it has long been engaged in, and an evidence of its activity will perhaps become apparent from the array of data in this Territory, the last in which savagery has been subjugated. Having reliable data upon the above points, the next subject of investigation is, what amount of waterflow becomes available, due allowance being made for evaporation, the selection of reservoir sites, and proportioning their size to the area of the catchment basin after a study of the drainage area in every particular. These latter questions are for the engineer.

The presentation of this paper and data will, it is hoped, go far to show that the meteorologist has been and is performing his functions, and that the engineering questions, it is believed, are ready to be actively entered upon.

The writer, under the stimulus of encouragement from General A. W. Greely, Chief Signal Officer, has collected climatic data recorded in the past, and established new stations in considerable number.

The results of this labor are partially presented in this data and discussion of rain-fall in Arizona, which follows:

Annual precipitation in Arizona.—The chart presenting the average annual precipitation embraces all stations in Arizona and includes a few outside near the boundary line and headwaters of the Gila in New Mexico. The average annual depth of rain-fall is found by taking the aggregate of the monthly averages, which latter are derived by adding the records of each month and dividing by the number of months of the same name taken.

In the southwestern and western portions of Arizona the precipitation is quite scant, being from about 2 to 6 inches, some places being perhaps as little as recorded at any place on the globe.

Rising into the more elevated districts of the eastern half, central, and northern parts, characterized as plateau and mountainous, the annual average ranges from 10 to 20 inches, and at a point just over the line in Utah is over 36 inches, and at the headwaters of the Gila 33 inches. It is proper to note in considering these averages that the points of observation are not on the tops of the mountains, nor even high on the slopes, but in most cases in valleys or cañons.

It is no uncommon sight to observe heavy rains in the mountains, or at the summits of ridges, while down their steep slopes flow great volumes of water, although at the spot where the gauge is located frequently not a sprinkle would fall. It is for this reason the data represents perhaps the least approximate quantity of actual precipitation.

The distribution of the rain-fall throughout the year is peculiar, there being distinctly two rainy seasons—one in the winter, the other in the summer. These dual wet seasons are very advantageous in renewing the supply to the streams in close succession. This peculiarity of Arizona rain-fall is particularly favorable in contrast to districts where there occurs a single rainy season, and balances largely any deficiency in quantity. Much of the precipitation occurs in the high plateau and mountain districts in the form of snow, which continues to lie on the northern slopes till late in the spring, while upon the higher mountains it does not disappear till late in June.

It is a noteworthy feature of the climatology of Arizona that with the disappearance of the last snows upon the mountain summits commences the summer rains. This fact affords quite a sure means of forecasting the beginning of the summer showers, which can be turned to advantage in husbanding, if necessary, water accumulated in storage reservoirs. It appears that the winter precipitation, though not so great, nor as sure to be relied upon as that of summer, has been observed never to fail to flood the streams each year, and besides its influence is prolonged in the melting of the snow.

This being followed by the mountain rains of the summer, it appears a natural provision largely balancing dearth of quantity.

The general character of the surface where the rain occurs being steep, rocky, and without thick forest growth, conduces to pass the greater portion of the water that falls down into the valleys at once. Especially is this true of the mountain sides where we have every reason to believe the fall of rain is quite great. At the summits, the rains of summer are of almost daily occurrence, and generally in the afternoons, often extending into the night.

The precipitation of midsummer is quite local in character, while that of winter is more uniform over the face of the country, irrespective of topographical features. One is caused by mountain influences, the other by the proximity of approach of great storms, in low pressure areas, that pass over the country.

The amount of rain-fall as a general rule, as instanced in the Atlantic States, is greatest in those districts that are situated toward the point from which the prevailing wind blows. The contrary, however, of this phenomena is found in Arizona and in the neighborhood of mountain ranges. The prevailing wind over Arizona is southwesterly, and it is on the leeward side of ranges that the greatest pluvial effort is

often found. Striking local instances may be observed in the records presented, when studied in connection with the location and topography. The record at Goodwin and Fort Thomas is a very noteworthy local instance, the former being under the flow of the wind from off Mount Turnbull.

The winter and summer rainy seasons.—The winter rains and snows generally occur within the months of December, January, and February. Sometimes they begin in November and rarely extend into March. The averages presented in the charts and in the table for these three months show quite well, however, the amounts that may be depended upon. The winter precipitation is largely in the form of snow, especially over the mountains and plateaus, and much remains unmelted till late in June, especially that falling on the north side of the higher mountain slopes. For this reason the ill effects of the nearly rainless period intervening between the end of the winter and the beginning of the summer rains is largely compensated by the melting snows which feed the streams.

The line of demarkation between the end of the summer and commencement of the winter rains is not so well defined. The summer rains, as above intimated, seem to begin as the snow disappears from the highest mountains, and continue during most of July, August, and September. Arizona is perhaps favored in having no mountains with summits above the perpetual snow line. To this absence the writer attributes the cause, at least a partial one, of the summer rains in Arizona. If the tops of the highest of the Sierra Nevada and Cascade Mountains could be cut off at their perpetual snow line, it is believed that there, too, the summer rains would prevail.

Contrasting Arizona with the Pacific coast States, if she has not so great an amount of rain-fall it comes differently distributed, and experience may prove the dual rainy seasons of Arizona have not unequal advantages with the single but greater one of those States.

The discussion of the cause of these different phenomena was touched upon in "Rain-fall of the Pacific Slope and the Western States and Territories," published by the United States Senate, in a letter transmitted by General A. W. Greely, Chief Signal Officer, and its repetition in this paper would perhaps be out of place.

The total amount of the summer rains is considerably in excess of that of winter, but comes in almost daily showers. It is rare that they occur as general rains over the whole face of the country, but instances are not lacking when the rain has fallen in down-pours and occasionally the term cloud-burst is not inappropriately descriptive. On the other hand, the winter precipitation is heavy and general while it lasts. It comes like that of the Pacific States, with storms conventionally known as cyclonic or low barometric areas, and the intervals between their occurrence are likewise characterized as cloudless. The variability of the winter rains in Arizona is about the same as that of the seasonal rains in California, that is in quantity and frequency, in a ratio to the intensity and recurrence of barometric disturbances. The effect of the rain-fall is obviously of an intermittent character. High and low water occurs in the streams during the rainy seasons, and during the periods of drought some streams become feeble rills or disappear altogether, except over some places where a solid rock stratum brings it to view. This disappearance of the streams is due to the great quantity of detritus, sand, and silt that has washed into the beds of the streams, on account of the sudden down-pours, and the steepness of the mountain sides.

This feature has given Arizona a reputation for drought and sterility largely undeserved. These conditions resulting in intermittent and for part of the year underground streams, with large volumes in winter, show the need of storage reservoirs to conserve the supply.

The most casual observer of the streams in Arizona during the winter is impressed with the fact that enough water pours down these rivers to water many times as much land as is possible of reclamation. These rises in the streams force us to repeat that the rain-gauge records show only a fraction of the actual precipitation that can be relied upon for water storage. It is during the summer only that the so-called cloud-bursts or down-pours of torrential rain occur. They are not frequent, however, but some are severe.

The maximum and minimum rain-fall.—The greatest and the least depth of precipitation is given for each month and year in tabular form; also in the charts is shown the greatest and least annual rain-fall for such stations as have a record of at least two years, or long enough to warrant its presentation as an approximate type. The minimum amount for any year is a very important item, too, in the consideration of water-storage systems, as it determines the water expectations of the most scanty precipitation seasons. When these amounts are viewed in connection with the great drainage areas, steepness, and character of the slopes there appears little or no doubt but the fall in years of drought even is sufficient for the most extensive reservoirs. The maximum annual rain-fall needs little mention, as it does not appear so great as to cause alarm. The greatest fall occurring within any number of consecutive hours, however, is more important, and the following table gives the aggregate number of

excessive monthly, daily, and hourly rain-falls reported at regular stations of the Signal Service in Arizona during the periods of observation, and the average interval of their occurrence:

Station.	1	2	3		4	5		6
			Yrs.	*Mos.*		*Yrs.*	*Mos.*	
Fort Apache	0	2	5	0	9	1	1	10
Fort Bowie	0	0	.....		0	.....		5
Fort Grant	0	3	3	4	6	1	8	10
Fort McDowell	0	1	5	0	0	.....		5
Fort Thomas	0	0	.....		1	8	0	8
Fort Verde	0	0	.....		0	.....		12
Maricopa	0	0	.....		0	.....		3
Phœnix	0	0	.....		0	.....		9
Prescott	0	2	6	0	0	.....		12
Yuma	0	0	.....		0	.....		13

In the table above column 1 represents rain-falls of 10 inches or more a month; 2, raine falls of 2.50 inches or more a day; 3, average interval of occurrence; 4, rain falls of 1 inch or more an hour; 5, average interval of occurrence; 6, length of record.

Practical examples of water storage in Arizona.—Arizona has but two complete projects for water storage for purposes of irrigation; one is a small reservoir at Woodruff in the northern part of the Territory. The Mormons operate it with marked success, as the flourishing villages in that community exemplify.

A more important project for water storage is found at Walnut Grove, near Prescott. This latter reservoir was principally built to hydraulic the placer or gold gravel deposits on the Hassayampa Creek, several miles below the basin in which the water is impounded.

This project may be looked upon as a type of what may be accomplished for irrigation works depending upon water storage for supply.

A careful estimate of the catchment basin of this reservoir shows it to be about 150 square miles. The few records of rain-fall within this area shows it to be much less than the recorded precipitation at Prescott, a few miles distant, where the least occurring during any year is 10 inches. The Walnut Grove reservoir is said to be capable of impounding 3,000,000,000 cubic feet of water. It is learned on good authority that this reservoir is full and was kept so during the scant rains of 1888. This actual exemplification shows the practicability of like storage systems on the Gila, Salt, Verde, and other streams, the only question apparently being the overcoming the abundance of water that sometimes occurs.

Proposed sites for surveys for storage reservoirs.—My own personal observations, supplemented by those of others, may not be inappropriate in this paper. During the past winter the writer, while on leave of absence, was engaged in surveys in southern Arizona, and examined especially the region about Florence, of which, through the kindness of Dr. J. M. Hurley, is presented a map with observations showing perhaps one of the most favorable spots in the country for water storage. The water-shed of the Gila River may be divided into two sections, the upper and the lower, the upper section extending from its source in the mountains of New Mexico, where the rain-fall, as shown by the tables, is phenomenally great, westward down its course to what is known as the Buttes, just above Florence, and a place where the mountains come together. At this point the bluffs are precipitous and the river flows through a narrow gorge not over 200 feet wide at the bottom. The lower Gila River extends from the Buttes down its course, and in a general westerly course for near 200 miles, to its confluence with the Colorado River at Yuma.

The topography, geography, geology, and productions of these two divisions are very dissimilar in many respects. A large portion of the upper Gila water-shed is very mountainous, the elevation varying from 2,000 to 10,000 feet. Some places show distinct traces of volcanic origin, the surface of the country being badly broken up. The soil is rich, consisting of decomposed granite, volcanic matter, and vegetable decomposition. Much of the more elevated portion is covered with a thick growth of timber, varying with the altitude from mere brush to the most gigantic pines on the mountains. In this section there are abundant rains, being heavy, as shown by the chart, during the summer, and considerable snow in the winter. Farming in some places may, indeed, be carried on without the aid of irrigation.

The rain-fall data presented in this water-shed is perhaps surprising. It is, too, no unusual thing to see snow from 3 to 7 feet deep on a level on the mountains. The lower section of the Gila Valley consists of vast plains interspersed with small mountains mostly of volcanic origin. The elevation of these plains varies from about 150, feet, near the Colorado River, to about 2,000 feet, at the Buttes near Florence. The soil of these plains consists of red clay, sand, and decomposed granite,

with vegetable matter washed from the mountains, it being perhaps the original bed of the ocean, that once covered this country. These plains are dry and barren, being covered sparsely with cacti, sage brush, and similar growth. In this section of the Gila Valley all crops are grown by the aid of irrigation. In extent this vast plain embraces thousands of acres, while the water supply as compared to the amount of land susceptible of cultivation is very limited, and unless ways and means are devised to store and save the immense floods of water from the upper Gila section, that semi-annually run to waste in the Gulf of California, there will be but a limited portion of these vast plains, of as good land as anywhere exists, ever brought under cultivation.

The canals taken from the Gila in the vicinity of Florence cover about 300,000 acres of land, including 50,000 acres on the Pima Indian Reservation. These canals nearly exhaust the water at ordinary stage, although they furnish a superabundance of water in the spring of the year in crop season, and also when the summer rains come early in the upper Gila, to make a second crop; but there occur usually two short periods in each year when there is a scarcity of water in all the lower valley, say, from three to six weeks in June and July and again about the same length of time in November and December; especially during the latter period is the amount needed usually limited.

When the water in the upper Gila gets low, immediately after it passes through the gorge at the Buttes, where the bed-rock comes to the surface, it largely disappears in the gravel bed that underlies the plains in the lower valley. Canals that are taken out immediately below the Buttes have a steady and constant supply of water, while those lower down get none in low water, except at a few places where the bed-rock comes to the surface. Notwithstanding this the entire volume of the river might be turned down to the lower sections if it were possible to raise the level of the water sufficiently through the agency of a reservoir. The many thousands of acres of the most valuable land in these lower plains before noted can be successfully brought under cultivation at a comparatively small cost to each acre by constructing a dam in the Gila River at the place above mentioned at the Buttes, some 10 miles above Florence.

A dam constructed there would store a sufficient quantity of water when the river is flush in the two rainy seasons to insure a steady flow of water in all the canals now in use in this valley, and allow a sufficient surplus of water to guaranty the construction of another canal to be taken out of the river at the Buttes on the south side of the river. The capacity of this canal can be as great as all other canals, and would water some of the finest land ever looked upon. This statement may seem an extravagant one, but upon examination of the accompanying map, showing the topography of the country above Florence, at and above the Buttes, it is readily seen that an enormous basin of water can be formed by constructing a dam at that place. It appears that a dam 150 feet high will back the water about 20 miles, giving probably an average depth of some 75 feet for the entire distance. The cañon of the river immediately above the Buttes widens out, and at a distance of one-fourth of a mile it is as much as one-half mile wide on the bottom, and much of the entire distance it is a mile or more wide. The sides of the mountain surrounding this basin are broken by side or lateral cañons that add greatly to the capacity of the basin. The conception of the capacity of such a reservoir can only be appreciated by the engineer and study of such spaces. No cross-sections of this basin have ever been made, as far as known, to calculate the vast volume of the basin, but the above statement it is believed is not overdrawn, and that an accurate survey will increase this estimate. There can be no doubt of the water supply being sufficient to fill this vast reservoir when a dam is once constructed, as a glance at the rain-fall data in the water-shed covering southwestern Arizona, a large part of western New Mexico and Sonora will prove. It is believed this water-shed will not only furnish water for this ideal reservoir, but will also supply many other reservoirs, smaller in capacity, that can be constructed at different places in the lower Gila River valley, and from which many thousands of acres of valuable land can be reclaimed.

The above facts seem to me so patent that it is respectfully urged that this place be investigated for early experiment and surveys in Arizona, under the Government, as there are few spots in the United States, and certainly few in Arizona, where so much can be accomplished with so small an expenditure of means. Indeed, to the person who has looked at the place with the object in view it appears as if nature had largely made this extraordinary place for the purpose.

A dam about 200 feet wide at the bottom and 100 feet high, though the height might be doubled, will, it is believed, accomplish the results heretofore outlined. At this place the best rock, almost in place, can be quarried for constructing the dam, and in the immediate vicinity good hydraulic lime can be burned, as is now done by the Mexicans for use by the cattle men for the purpose of constructing water tanks. With all these advantages, and many others not enumerated that will be found to *exist* when properly examined, the Government can not too early turn its attention

to this extraordinary place, that it may be utilized while it is yet unencumbered by settlers or other claims, so that this, if the first experiment in the storage of water from large streams, may be a success beyond a question.

Some action in this direction by the Government is essential, as the work is of such magnitude that it deters private capital from undertaking it until prominent engineers have pronounced the proposition feasible beyond a doubt.

The Salt and Verde Rivers.—Having noted the advantages for the impounding of water on the Gila, it would perhaps be unjust to fail in mentioning the existence of quite similar facilities reputed to exist in the Salt, or Salido, and the Verde Rivers. Of these the writer has made less investigation, and consequently speaks in a general way, having traversed each river nearly from their sources to their confluence, which is 40 miles northwest of the Buttes of the Gila. The Salt and Verde Rivers are the third and fourth largest streams in size in the extreme southwestern portion of the Union. These rivers after a tortuous course of hundreds of miles through deep cañons and natural basins, whose areas are measured by hundreds of miles, at their junction debranch into a series of mesa lands, noted for their fertility and extent. Of these lands over a quarter of a million acres within the last few years have by the construction of irrigating ditches been rendered susceptible of raising every variety of semi-tropical fruits that have made California so justly famous, while villages and cities numbering some hundreds, and others thousands, of inhabitants have sprung into existence. That the amount of land that can be now cultivated is but a small moiety of what has been is proved by the fact that far outside the ditches, constructed by the white residents, are to be found the remains of prehistoric canals and acequias, which in places can be traced for miles.

These prehistoric works of irrigation were in their day probably rendered possible by the rivers mentioned occupying, in the vicinity of the military post of Fort McDowell, higher levels than they do at present, levels now made impracticable through the wearing away and lowering by natural causes of the river-beds. The above causes may have been aided by volcanic or seismic action; the evidence of the recent occurrence of the first is well shown by beds of lava-flow, into and across the canals of these prehistoric people, and evidences of earthquake changes abound on every hand. While these causes were lowering the levels of the streams, they were at the same time forming a system of over-drainage through and by which natural basins that were once the beds of lakes were provided with outlets that prevented the accumulation of any quantities of water. So excessive is this natural system of overdrainage that in the water-sheds of the Verde and Salt Rivers, the great magnitude of which an observant glance at any hypsometric map of these areas will reveal, there is not to be found a single lake of any extent, although the evidences of the recent existence of such bodies of considerable size are so common as to excite but little comment. Some of these basins on the rivers mentioned equal in area some of the smaller States, and only need closing of the outlets created by the action of the streams to be reconverted into immense lakes, whose catchment capacity would be such as to provide water sufficient to reclaim the millions of acres, which in southern Arizona slope gradually away to the southwest toward the Gulf of California.

How vast an amount of water under the present condition of affairs yearly finds its way without being utilized through the channels of these rivers to the sea may be realized when it is remembered that the average annual rain-fall on the water-shed of the Salt River is shown to be about 20 inches and that of the Verde ranging from 20 to 10 inches. Year after year sees the demand upon these streams for water for irrigation become more and more difficult to fill, not on account of scarcity of water so much as by reason of the waste that is permitted during the wet seasons.

The catchment to any considerable extent of the rain-fall annually occurring on the water-shed of the Gila, Salt, or Verde River would not only insure an abundance for all present requirements, but make possible the reclamation of a vast territory that otherwise will always remain desert.

The following tables and charts are in illustration:

No. III.

Greatest and least rain-fall, by months and years, Arizona.

Stations.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
		In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Apache, Fort, Ariz.	Max	3.90	3.43	4.44	1.77	1.31	3.27	5.83	9.33	5.41	4.68	2.63	5.52	31.12
	Min.	.18	.88	.03	.08	.00	T.	.14	1.20	.32	.00	.02	.22	12.41
Benson, Ariz	Max	.93	1.20	2.08	T.	.37	.86	2.97	4.33	2.92	2.89	1.11	2.50	.....
	Min.	.00	.00	.00	.00	.00	.00	.58	.27	.05	.00	.00	.15	.....
Bowie, Fort, Ariz.	Max	4.24	5.40	4.48	1.00	1.50	4.21	7.90	7.44	3.19	3.58	1.79	6.41	25.20
	Min	.00	.20	.00	.00	.00	.00	.50	.18	.01	.00	.00	.00	9.36
Buchanan, Ft., Ariz	Max.	2.35	2.92	.47	1.46	.55	1.96	9.24	10.60	4.76	2.33	2.84	2.58	25.82
	Min.	.54	.51	.00	.00	.00	.20	3.21	3.50	.74	.60	.00	.40	16.08
Casa Grande, Ariz.	Max.	.90	.40	1.08	.30	.24	.40	1.07	2.37	1.90	1.31	1.28	3.20	8.71
	Min.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.02
Colorado, C'p, Ariz.	Max	.30	.21	.50	.15	.05	.00	.06	.30	.00	.50	1.00	.20	2.61
	Min.	.00	.00	.00	.00	.00	.00	.00	.20	.00	.10	.00	.20	1.31
Crittend'n, C'p, Ariz	Max.	1.10	2.50	1.13	.39	.20	.68	11.72	5.55	1.55	.46	1.01	3.76	19.08
	Min.	.31	.19	.00	.00	.00	.00	3.17	4.07	.40	.00	.00	.40	15.53
Date Cr'k, C'p, Ariz	Max.	3.12	2.85	2.86	2.05	.63	1.49	7.24	8.30	.93	1.50	1.90	4.09	27.84
	Min.	.00	.70	.00	.00	.00	.00	.36	.84	.00	.00	.00	.06	13.60
Defiance, Ft., Ariz	Max.	2.86	1.71	3.30	1.64	1.51	2.35	5.77	5.24	3.47	1.73	4.30	1.59	22.44
	Min.	.02	.03	.00	.02	.00	.10	.90	.30	.49	.00	.15	.23	11.63
Florence, Ariz	Max.	2.88	1.15	2.83	1.55	.31	.07	4.53	4.28	2.75	1.29	1.37	2.12	13.49
	Min	.00	.00	T.	.00	.00	.00	.00	.13	.26	.00	.00	.00	5.35
Goodwin, Ariz	Max.	5.77	2.62	1.87	2.67	.01	2.06	3.39	14.45	10.40	3.70	2.40	5.20	27.93
	Min.	.20	.58	.02	.00	.00	.00	3.20	2.16	.02	.50	.41	.60	16.00
Grant, Fort, Ariz	Max.	2.48	4.62	1.04	3.11	1.16	1.47	9.00	7.41	4.65	3.06	3.38	5.93	25.67
	Min.	.00	.10	.00	.00	.00	.00	.67	.52	.00	.00	.00	.09	8.95
Harrisburg, Utah	Max.	.15	4.50	2.10	2.10	2.25	.....	3.60	.80	.....	.....	3.15	.10	.....
	Min.	.05	.95	.10	.10	2.15	.....	.90	.50	.....	.....	.70	.01	.....
Holbrook, Ariz	Max.	1.00	1.18	1.24	.82	.29	.56	1.98	2.09	1.88	1.05	2.20	1.31	10.82
	Min.	.10	.29	.06	.10	.00	.05	.47	.74	.51	.50	.14	.40	6.92
Hualpai, C'p, Ariz.	Max.	.10	4.65	.00	1.97	1.18	3.60	4.91	6.40	4.10	.60	.50	1.70	.....
	Min.	.00	.40	.00	.07	.10	.00	2.30	2.80	2.20	.30	.00	.20	.....
Kanab, Utah	Max	3.30	3.55	1.75	1.80	1.80	2.10	1.50	.50	1.25	4.40	3.20	6.50	14.60
	Min.	.00	.05	.00	.06	.00	.00	.00	.00	.00	.00	.00	.00	7.37
Lordsburg, N.Mex.	Max.	.92	.45	4.00	.20	.40	.30	3.17	3.45	2.35	2.55	1.50	1.46	13.09
	Min.	.00	.10	.00	.00	.00	.00	.75	.35	.00	.00	.00	.00	5.50
Lowell, Fort, Ariz.	Max.	4.74	5.23	2.90	1.09	.42	2.05	4.83	7.88	3.83	2.65	2.30	3.18	14.69
	Min.	.00	.00	.00	.00	.00	.00	T.	.34	.00	.00	.00	.00	6.21
Maricopa, Ariz	Max.	1.32	.60	2.83	.51	.41	.45	1.26	1.29	1.10	1.51	.70	2.97	11.96
	Min.	.00	.00	T.	.00	.00	.00	.16	.08	T.	.00	.00	.00	.38
McDowell, Ft., Ariz	Max.	3.35	4.37	.76	3.20	1.04	1.00	9.16	7.17	4.11	2.82	2.76	5.70	20.01
	Min.	.00	.00	.00	.00	.00	.00	.00	.06	.00	.00	.00	.00	4.94
Mt Carmel, Utah	Max.	16.00	11.90	10.00	4.40	6.25	.08	3.25	4.25	1.50	18.75	4.50	1.40	58.05
	Min.	1.05	4.00	.50	1.25	.20	.00	.00	.00	.00	.20	.00	.00	22.50
Mojave, Fort, Ariz.	Max.	4.15	5.00	2.50	4.05	1.20	1.00	1.80	3.80	.83	2.00	6.16	5.69	14.35
	Min.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.23
Pantano, Ariz	Max.	2.02	2.80	2.08	.88	.60	.99	4.51	5.74	1.50	2.80	1.83	4.70	13.86
	Min.	.00	.41	.00	.00	.00	.00	T.	1.63	.00	.00	.00	.00	8.96
Phœnix, Ariz	Max.	1.62	2.46	2.85	1.25	.65	.49	2.40	2.19	1.50	1.12	1.66	3.36	12.83
	Min.	.00	.17	.00	.00	.00	.00	.05	.02	.07	.00	.00	.00	3.77
San Carlos, Ariz	Max.	2.88	3.83	3.97	.84	.71	1.09	4.13	6.05	1.94	1.73	1.76	5.48	20.41
	Min.	T.	.93	.00	.00	.00	.00	.03	.40	.11	.00	.00	.00	8.19
San Simon, Ariz	Max.	.50	.78	2.21	.10	.34	.08	1.25	3.60	2.24	1.63	.35	1.03	.....
	Min.	.01	.05	.00	.00	.00	.00	.00	T.	.00	.00	.00	T.	.....
Silver City, N.Mex.	Max.	2.78	2.06	1.57	.48	1.37	1.92	9.62	8.69	3.89	3.21	3.81	1.65	30.82
	Min.	.02	.63	.32	.01	.00	.08	1.37	3.51	.27	.00	.00	.28	13.77
St. George, Utah	Max.	2.44	.98	1.30	.52	10.00	.04	1.03	1.17	.98	1.36	1.03	1.30	.....
	Min.	.85	.43	.01	.04	.00	.01	.22	.11	.20	.80	.23	.94	.....
Tucson, Ariz	Max.	2.02	2.50	1.77	1.09	.41	.99	5.72	6.32	3.83	1.50	2.06	3.90	16.66
	Min.	.00	.15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	6.61
Verde, Fort, Ariz.	Max.	2.91	3.59	3.60	1.75	1.70	1.35	5.31	12.80	4.72	4.47	4.04	4.66	21.40
	Min.	.00	.00	.06	.00	.00	.00	.07	.26	.00	.00	.00	.00	4.80
Wallen, Camp, Ariz.	Max.	4.60	2.30	.67	.50	.10	.05	7.90	8.00	2.00	.00	.00	7.90	24.53
	Min.	1.10	.50	.30	.00	.00	.00	1.40	2.50	.20	.00	.00	.00	17.76
Whipple, Ft., Ariz.	Max.	5.09	6.55	8.00	2.86	1.82	1.24	7.98	6.34	4.88	1.75	3.18	5.58	27.13
	Min.	.00	.01	.00	.03	.00	.00	.61	.24	.00	.00	.00	.00	10.02
Webster, Fort, N. Mex	Max.	.....	1.51	.13	4.45	1.23	4.89	4.79	4.29	3.47	1.19	3.48	.30	29.73
	Min.	.....	.50	.00	.00	1.05	1.08	2.55	1.21	1.26	.40	.26	.08	8.79
Wickenburgh, Ariz	Max.	2.73	4.21	3.67	1.24	.64	.06	2.29	5.02	1.16	.58	1.69	5.27	17.17
	Min.	T.	.00	.00	.13	.00	.00	.09	.05	.04	.00	.00	.00	6.35
Willcox, Ariz	Max.	1.25	1.83	1.95	.04	.48	.47	3.97	5.31	2.96	3.59	4.25	3.49	18.38
	Min.	T.	.31	.00	.00	.00	T.	.11	.52	.04	.00	.00	.00	11.15
Willow Grove, Ariz	Max	.48	1.15	.42	1.02	.28	.07	4.67	2.73	.14	.33	.23	.35	.....
	Min	.48	.61	.42	.16	.12	.00	1.43	2.01	.00	.33	.23	.35	.....
Wingate, Fort, N. Mex	Max	3.30	11.25	4.95	2.70	3.00	3.15	7.60	5.90	3.60	4.60	4.10	2.75	25.06
	Min.	.10	.00	.00	.00	.00	.00	.26	.24	.00	.00	.00	.00	5.69
Yuma, Ariz	Max.	1.35	1.72	5.01	.55	.44	.05	.55	2.23	1.09	1.11	2.43	1.96	7.77
	Min.	.00	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.74

No. II.

Average summer and winter rain-fall, Arizona.

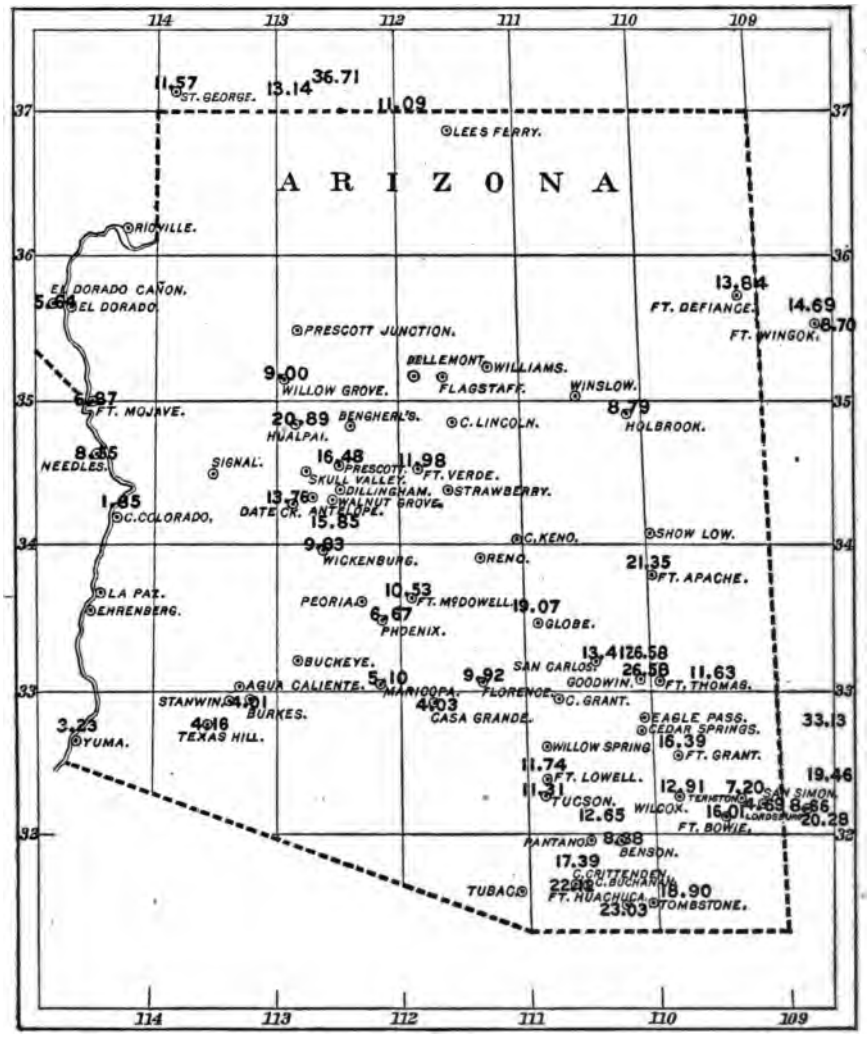
Stations.	December, January, February	July, August, September.	Stations.	December, January, February.	July, August, September.
Antelope, Valley, Ariz	5.52	2.58	McDowell, Fort, Ariz	4.10	3.84
Apache, Fort, Ariz	4.77	10.30	Mount Carmel, Utah	13.51	3.41
Ash Cañon, Ariz	6.35	.....	Mojave, Fort, Ariz	2.64	.99
Benson, Ariz	1.61	4.95	Needles, Cal	3.98	.81
Bowie, Fort, Ariz	4.61	7.58	Pantano, Ariz	3.35	5.96
Buchanan, Fort, Ariz	4.63	13.44	Phœnix, Ariz	2.30	2.24
Burks, Ariz	1.37	2.00	Reno, Camp, Ariz	5.86	.....
Casa Grande, Ariz	1.32	1.49	San Carlos, Ariz	4.53	5.25
Cedar Springs, Ariz	5.93	1.48	San Simon, Ariz	.91	2.55
Colorado, Camp, Ariz	.42	.28	Silver City, N. Mex	3.25	12.15
Coolidge, N. Mex	2.20	.....	St. George, Utah	3.33	1.84
Crittenden, Camp, Ariz	3.64	11.83	Teviston, Ariz	2.08	.37
Date Creek, Camp, Ariz	3.34	7.26	Texas Hill, Ariz	1.48	1.15
Defiance, Fort, Ariz	2.32	7.05	Thomas, Fort, Ariz	2.46	5.18
Eagle Pass, Ariz	6.77	.....	Tubac, Ariz	3.67	.....
Eldorado Cañon, Cal	2.71	.94	Tucson, Ariz	2.67	5.65
Florence, Ariz	2.62	4.70	Tularosa, Fort, N. Mex	14.26	13.25
Globe, Ariz	5.44	4.49	Verde, Fort, Ariz	3.17	4.79
Goodwin, Ariz	7.04	13.93	Wallen, Ariz	6.95	11.21
Grant, Fort, Ariz	3.59	8.72	Whipple, Fort, Ariz	4.36	7.11
Harrisburg, Utah	3.10	3.62	Webster, Fort, Ariz	1.59	8.78
Holbrook, Ariz	1.95	3.44	Wickenburgh, Ariz	4.04	3.46
Huachuca, Fort, Ariz	3.75	11.67	Willcox, Ariz	2.90	6.65
Hualpai, Camp, Ariz	2.88	13.77	Winslow, Ariz	.....	1.80
Kanab, Utah	4.71	1.96	Williams, Ariz	6.20	.....
Lordsburg, N. Mex	1.31	4.76	Willow Grove, Ariz	1.71	5.49
Lowell, Fort, Ariz	3.22	6.42	Wingate, N. Mex	3.69	6.10
Maricopa, Ariz	1.71	1.63	Yuma, Ariz	1.32	.70

No. III.

Greatest and least rain-fall, by months and years, Arizona.

Stations.		Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
		In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
Apache, Fort, Ariz.	Max	3.90	3.43	4.44	1.77	1.31	3.27	5.83	9.33	5.41	4.68	2.63	5.52	31.12
	Min	.18	.88	.03	.08	.00	T.	.14	1.20	.32	.00	.02	.22	12.41
Benson, Ariz	Max	.93	1.20	2.08	T.	.37	.86	2.97	4.33	2.92	2.89	1.11	2.50	.....
	Min	.00	.00	.00	.00	.00	.00	.58	.27	.05	.00	.00	.15	.....
Bowie, Fort, Ariz.	Max	4.24	5.40	4.48	1.00	1.50	4.21	7.90	7.44	3.19	3.58	1.79	6.41	25.20
	Min	.00	.20	.00	.00	.00	.00	.50	.18	.01	.00	.00	.00	9.36
Buchanan, Ft., Ariz	Max	2.35	2.92	.47	1.46	.55	1.96	9.24	10.60	4.76	2.33	2.84	2.58	25.82
	Min	.54	.51	.00	.00	.00	.20	3.21	3.50	.74	.60	.00	.40	16.08
Casa Grande, Ariz.	Max	.90	.40	1.08	.30	.24	.40	1.07	2.37	1.90	1.31	1.28	3.20	8.71
	Min	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.02
Colorado, C'p, Ariz.	Max	.30	.21	.50	.15	.05	.00	.06	.30	.00	.50	1.00	.20	2.61
	Min	.00	.00	.00	.00	.00	.00	.00	.20	.00	.10	.00	.20	1.31
Crittend'n, C'p, Ariz	Max	1.10	2.50	1.13	.39	.20	.68	11.72	5.55	1.55	.46	1.01	3.76	19.08
	Min	.31	.19	.00	.00	.00	.00	3.17	4.07	.40	.00	.00	.40	15.53
Date Cr'k, C'p, Ariz	Max	3.12	2.85	2.86	2.05	.63	1.49	7.24	8.30	.93	1.50	1.90	4.09	27.84
	Min	.00	.70	.00	.00	.00	.00	.36	.84	.00	.00	.00	.06	13.60
Defiance, Ft., Ariz	Max	2.86	1.71	3.30	1.64	1.51	2.35	5.77	5.24	3.47	1.73	4.30	1.59	22.44
	Min	.02	.03	.00	.02	.00	.10	.00	.30	.49	.00	.15	.23	11.63
Florence, Ariz	Max	2.88	1.15	2.83	1.55	.31	.07	4.53	4.28	2.75	1.29	1.37	2.12	13.49
	Min	.00	.00	T.	.00	.00	.00	.00	.13	.26	.00	.00	.00	5.35
Goodwin, Ariz.	Max	5.77	2.62	1.87	2.67	.01	2.06	3.39	14.45	10.40	3.70	2.40	5.20	27.93
	Min	.20	.58	.02	.00	.00	.00	3.20	2.16	.02	.50	.41	.60	16.00
Grant, Fort, Ariz	Max	2.48	4.62	1.04	3.11	1.16	1.47	9.00	7.41	4.65	3.06	3.38	5.93	25.67
	Min	.00	.10	.00	.00	.00	.00	.67	.52	.00	.00	.00	.09	8.95
Harrisburg, Utah	Max	.15	4.50	2.10	2.10	2.25	.....	3.60	.80	.....	.....	3.15	.10	.....
	Min	.05	.95	.10	.10	2.15	.....	.90	.50	.....	.....	.70	.01	.....
Holbrook, Ariz	Max	1.00	1.18	1.24	.82	.29	.56	1.98	2.09	1.88	1.05	2.20	1.31	10.82
	Min	.10	.29	.06	.10	.00	.05	.47	.74	.51	.50	.14	.40	6.92
Hualpai, C'p, Ariz	Max	.10	4.65	.00	1.97	1.18	3.60	4.91	6.40	4.10	.60	.50	1.70	.....
	Min	.00	.40	.00	.07	.10	.00	2.30	2.80	2.20	.30	.00	.20	.....
Kanab, Utah	Max	3.30	3.55	1.75	1.80	1.80	2.10	1.50	.50	1.25	4.40	3.20	6.50	14.60
	Min	.00	.05	.00	.06	.00	.00	.00	.00	.00	.00	.00	.00	7.37
Lordsburg, N.Mex.	Max	.92	.45	4.00	.20	.40	.30	3.17	3.45	2.35	2.55	1.50	1.46	13.09
	Min	.00	.10	.00	.00	.00	.00	.75	.35	.00	.00	.00	.00	5.50
Lowell, Fort, Ariz	Max	4.74	5.23	2.90	1.09	.42	2.05	4.83	7.88	3.83	2.65	2.30	3.18	14.69
	Min	.00	.00	.00	.00	.00	.00	T.	.34	.00	.00	.00	.00	6.21
Maricopa, Ariz	Max	1.32	.60	2.83	.51	.41	.45	1.26	1.29	1.10	1.51	.70	2.97	11.96
	Min	.00	.00	T.	.00	.00	.00	.16	.08	T.	.00	.00	.00	.38
McDowell, Ft., Ariz	Max	3.35	4.37	.76	3.20	1.04	1.00	9.16	7.17	4.11	2.82	2.76	5.70	20.01
	Min	.00	.00	.00	.00	.00	.00	.00	.06	.00	.00	.00	.00	4.94
Mt Carmel, Utah	Max	16.00	11.90	10.00	4.40	6.25	.08	3.25	4.25	1.50	18.75	4.50	1.40	58.05
	Min	1.05	4.00	.50	1.25	.20	.00	.00	.00	.00	.20	.00	.00	22.50
Mojave, Fort, Ariz	Max	4.15	5.00	2.50	4.05	1.20	1.00	1.80	3.80	.83	2.00	6.16	5.69	14.35
	Min	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.23
Pantano, Ariz	Max	2.02	2.80	2.08	.88	.60	.99	4.51	5.74	1.50	2.80	1.83	4.70	13.86
	Min	.00	.41	.00	.00	.00	.00	T.	1.63	.00	.00	.00	.00	8.96
Phœnix, Ariz	Max	1.62	2.46	2.85	1.25	.65	.49	2.40	2.19	1.50	1.12	1.66	3.36	12.83
	Min	.00	.17	.00	.00	.00	.00	.05	.02	.07	.00	.00	.00	3.77
San Carlos, Ariz	Max	2.88	3.83	3.97	.84	.71	1.09	4.13	6.05	1.94	1.73	1.76	5.48	20.41
	Min	T.	.93	.00	.00	.00	.00	.03	.40	.11	.00	.00	.00	8.19
San Simon, Ariz	Max	.50	.78	2.21	.10	.34	.08	1.25	3.60	2.24	1.63	.35	1.03	.....
	Min	.01	.05	.00	.00	.00	.00	.00	T.	.00	.00	.00	T.	.....
Silver City, N.Mex.	Max	2.78	2.06	1.57	.48	1.37	1.92	9.62	8.69	3.89	3.21	3.81	1.65	30.82
	Min	.02	.63	.32	.01	.00	.08	1.37	3.51	.27	.00	.00	.28	13.77
St. George, Utah	Max	2.44	.98	1.30	.52	10.00	.04	1.03	1.17	.98	1.36	1.03	1.30	.....
	Min	.85	.43	.01	.04	.00	.01	.22	.11	.20	.80	.23	.94	.....
Tucson, Ariz	Max	2.02	2.50	1.77	1.09	.41	.99	5.72	6.32	3.83	1.50	2.06	3.90	16.66
	Min	.00	.15	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	6.61
Verde, Fort, Ariz	Max	2.91	3.59	3.60	1.75	1.70	1.35	5.31	12.80	4.72	4.47	4.04	4.66	21.40
	Min	.00	.00	.06	.00	.00	.00	.07	.26	.00	.00	.00	.00	4.80
Wallen, Camp, Ariz.	Max	4.60	2.30	.67	.50	.10	.05	7.90	8.00	2.00	.00	.00	7.90	24.53
	Min	1.10	.50	.30	.00	.00	.00	1.40	2.50	.20	.00	.00	.00	17.76
Whipple, Ft., Ariz.	Max	5.09	6.55	8.00	2.86	1.82	1.24	7.98	6.34	4.88	1.75	3.18	5.58	27.13
	Min	.00	.01	.00	.03	.00	.00	.61	.24	.00	.00	.00	.00	10.02
Webster, Fort, N. Mex	Max	.....	1.51	.13	4.45	1.23	4.89	4.79	4.29	3.47	1.19	3.48	.30	29.73
	Min	.....	.50	.00	.00	1.05	1.08	2.55	1.21	1.26	.40	.26	.08	8.79
Wickenburgh, Ariz	Max	2.73	4.21	3.67	1.24	.64	.06	2.29	5.02	1.16	.58	1.69	5.27	17.17
	Min	T.	.00	.00	.13	.00	.00	.09	.05	.04	.00	.00	.00	6.35
Willcox, Ariz	Max	1.25	1.83	1.95	.04	.48	.47	3.97	5.31	2.96	3.59	4.25	3.49	18.38
	Min	T.	.31	.00	.00	.00	T.	.11	.52	.04	.00	.00	.00	11.15
Willow Grove, Ariz	Max	.48	1.15	.42	1.02	.28	.07	4.67	2.73	.14	.33	.23	.35	.....
	Min	.48	.61	.42	.16	.12	.00	1.43	2.01	.00	.33	.23	.35	.....
Wingate, Fort, N. Mex	Max	3.30	11.25	4.95	2.70	3.00	3.15	7.60	5.90	3.60	4.60	4.10	2.75	25.06
	Min	.10	.00	.00	.00	.00	.00	.26	.24	.00	.00	.00	.00	5.69
Yuma, Ariz	Max	1.35	1.72	5.01	.55	.44	.05	.55	2.23	1.09	1.11	2.43	1.96	7.77
	Min	.00	.00	.00	.00	00	.00	.00	.00	.00	.00	.00	.00	.74

No. IV.—*Average annual rain-fall for Arizona Territory.*

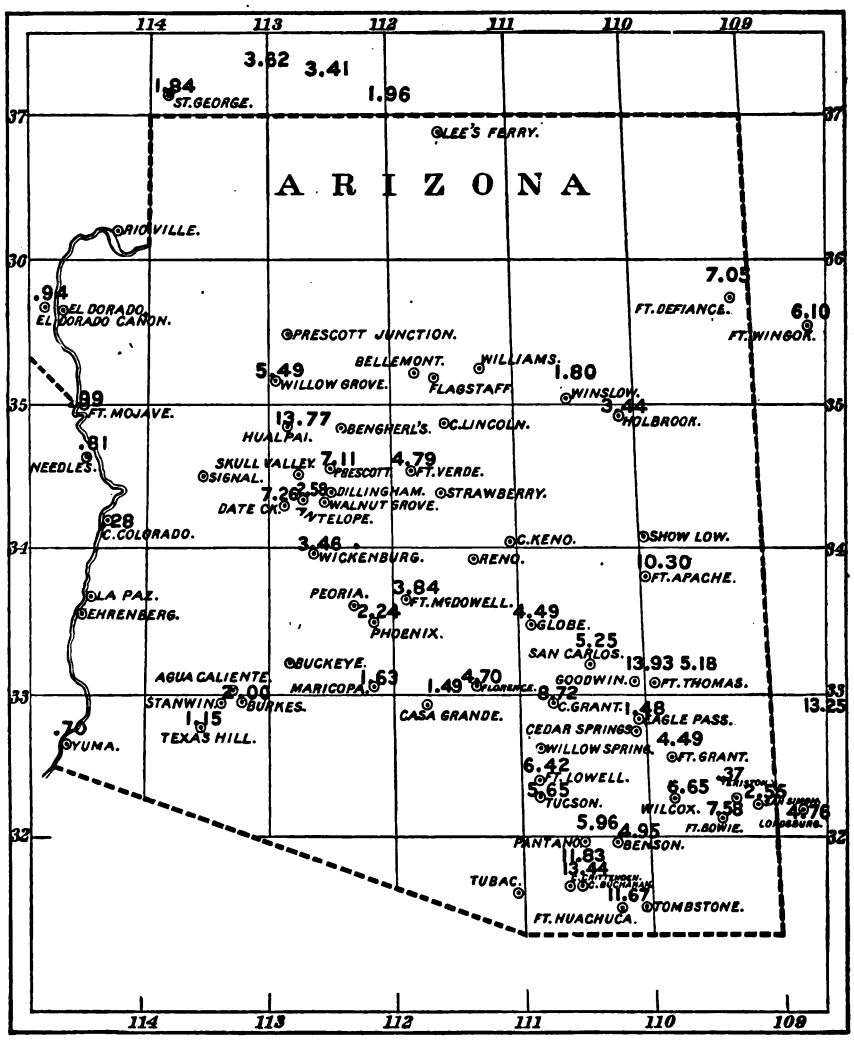


No. V.—*Greatest annual rain-fall, Arizona Territory.*

No. VI.—*Least annual rain-fall, Arizona Territory.*

No. VII.—*Average rain-fall for December, January, and February.*

No. VIII.—*Averages for July, August, and September.*



IRRIGATION LAWS OF ARIZONA.

TITLE LXIII.—WATERS AND WATER RIGHTS.

CHAPTER 1.—*Riparian rights.*

[Approved March 10, 1887.]

3198. (Sec. 1.) The common-law doctrine of riparian rights shall not obtain or be of any force or effect in this Territory.

CHAPTER 2.—*Irrigating canals and acequias.*

3199. (Sec. 1.) All rivers, creeks, and streams of running water in the Territory of Arizona are hereby declared public and applicable to the purposes of irrigating and mining, as hereinafter provided.

3200. (Sec. 2.) All rights in acequias, or irrigating canals, heretofore established shall not be disturbed, nor shall the course of such acequias be changed without the consent of the proprietors of such established rights.

3201. (Sec. 3.) All the inhabitants of this Territory who own or possess arable and irrigable lands shall have the right to construct public or private acequias, and obtain the necessary water for the same from any convenient river, creek, or stream of running water.

3202. (Sec. 4.) Whenever such public or private acequias shall necessarily run through the lands of any private individuals not benefited by said acequias, the damages resulting such private individuals, on the application of the party interested, shall be assessed by the probate judge of the proper county in a summary manner.

3203. (Sec. 5.) No inhabitant of this Territory shall have the right to erect any dam, or build a mill, or place any machinery, or open any sluice, or make any dyke, except such as are used for mining purposes or the reduction of metals, as provided for in sections 6 and 7 of this chapter, that may impede or obstruct the irrigation of any lands or fields, as the right to irrigate the fields and arable lands shall be preferable to all others; and the justices of the peace of the respective precincts shall hear and determine the question relative to all such obstructions in a summary manner, and cause the removal of the same by order directed to the constable of the precincts or sheriff of the county, who shall proceed to execute the same without delay.

3304. (Sec. 6.) Where reduction works or other mining apparatus shall be placed upon lands previously held for agricultural purposes, or persons so holding such lands shall be entitled to remuneration from person or persons erecting or owning said reduction works or mining apparatus, the amount of remuneration shall be adjudged by three or five disinterested persons, or by the probate judge, as the parties interested shall agree; and in case such agreement can not be made, then the party injured may bring suit for damages.

3205. (Sec. 7.) When any ditch or acequia shall be taken out for agricultural purposes, the person or persons so taking out such ditch or acequia shall have the exclusive right to the water, or so much thereof as shall be necessary for said purposes; and if at any time the waters so required shall be taken for mining operations, the person or persons owning said water shall be entitled to damages to be assessed in the manner provided in section 6 of this chapter.

3206. (Sec. 8.) All by-paths or footpaths across any cultivated fields are prohibited, under penalty of a fine not to exceed $10 for the public acequia, to be assessed in a summary manner by the justice of the peace of the precinct; and if the person so offending shall not have wherewith to pay the fine, he shall be adjudged and sentenced to ten days on the public acequia.

3207. (Sec. 9.) All owners of arable and irrigable land bordering on, or irrigable by, any public acequia, shall labor on such public acequia, whether such owners or proprietors cultivate the land or not.

3208. (Sec. 10.) All persons interested in a public acequia, whether owners or lessees of land, shall labor thereon in proportion to the amount of land owned or held by them, and which may be irrigated or subject to irrigation.

3209. (Sec. 11.) It being impracticable to properly inclose the fields in this Territory, all animals shall be kept under a shepherd so that no injury may result to the fields; and if any damage should result, it shall be paid by the owners of the animals

causing the same, to be assessed by the justice of the peace of the precinct in a summary manner, and paid to the person or persons whose fields may have been damaged.

3210. (Sec. 12.) In case a community or people desire to construct an acequia in any part of this Territory, and the persons desiring to construct the same are the owners or proprietors of the land upon which they design constructing the said acequia, no one shall be bound to pay damages for such land, as all persons interested in the construction of the said acequia are to be benefited thereby.

3211. (Sec. 13.) Immediately after the publication of this chapter, it shall be the duty of the several justices of the peace in this Territory to call together, in their respective precincts, all the owners and proprietors of land, irrigated by any public acequia, for the purpose of electing one or more overseers for said acequia for the corresponding year.

3212. (Sec. 14.) The manner of conducting such elections, and the number of overseers, shall be regulated by the justices of the peace of their respective precincts; and the only persons entitled to vote at said elections shall be the owners and proprietors of lands irrigated by said acequias.

3213. (Sec. 15.) The pay and perquisites of said overseer shall be determined by a majority of the owners and proprietors of the lands irrigated by said acequias, and paid by them.

3214. (Sec. 16.) It shall be the duty of the overseers to superintend the opening, excavations and repairs of said acequias; to apportion the number of laborers furnished by the owners, and proprietors; to regulate them according to the quantity of land to be irrigated by each one from said acequia, to distribute and apportion the water in proportion to the quantity to which each one is entitled according to the land cultivated by him; and, in making such apportionment, he shall take into consideration the nature of the seed sown or planted, the crops and plants cultivated; and to conduct and carry on such distribution with justice and impartiality.

3215. (Sec. 17.) During years when a scarcity of water shall exist, owners of fields shall have precedence of the water for irrigation, according to the dates of their respective titles or their occupation of the lands, either by themselves or their grantors. The oldest titles shall have precedence always.

3216. (Sec. 18.) It shall be the duty of each of the owners and proprietors to furnish the number of laborers required by the overseer, at the time and place he may designate, for the purposes mentioned in the foregoing section, and for the time he may deem necessary.

3217. (Sec. 19.) If any overseer of any public acequira after having undertaken to serve as such, shall wilfully neglect or refuse to fulfill the duties required of him by this chapter, or conduct himself with impropriety or injustice in his office as overseer; or take any bribe in money, property or otherwise, as an inducement to act improperly; or neglect the duties of his office, he shall be fined for each of said offenses in a sum not exceeding $100 nor less than $50, to be recovered before any justice of the peace of the county—one-half of which shall be paid to the county, and the other half to the person bringing suit for the same,—the said suit to be brought in the name of the Territory of Arizona; and said overseer, on being convicted a second time, shall be removed from his office by the justice of the peace of the precinct, and shall take such pay and perquisites as may be due him for services rendered.

3218. (Sec. 20.) Upon such removal, the justice of the peace shall order a new election to fill the vacancy thereby occasioned, which shall be conducted in the manner prescribed in the thirteenth and fourteenth sections of this chapter.

3219. (Sec. 21.) If any owner or proprietor of land irrigated by such acequia shall neglect or refuse to furnish the number of laborers required by the overseer, as required in the eighteenth section of this chapter after having been duly notified by the overseer, he shall be fined for each offense in a sum not exceeding $10 for the benefit of said acequia, which shall be recovered by the overseer before any justice of the peace in the county, and in such cases, the overseer shall be a competent witness to prove the offense or any fact that may serve to constitute the same.

3220. (Sec. 22.) If any person shall in any manner interfere with, impede or obstruct any of said acequias, or use the water from it without the consent of the overseer, except as provided in section 7 of this chapter, during the time of cultivation, he shall pay for each offense a sum not exceeding $10, which shall be recoverable in the manner prescribed in the foregoing section for the benefit of said acequia; and he shall further pay all damages that may have accrued to the injured parties, and, if such person have not wherewith to pay said fine and damages, he shall be sentenced to fifteen days labor on said public acequia.

3221. (Sec. 23.) All fines and forfeitures received for the use and benefit of any public acequia, shall be applied by the overseers to the improvements, excavations and repairs which may be necessary on said acequia, and for the construction of bridges where they may be crossed by any public street or road.

3222. (Sec. 24.) In all cases of conviction under this chapter, an appeal shall be allowed to the probate court, which appeal shall be taken and conducted as all other appeals from the decisions of the justices of the peace.

3223. (Sec. 25.) The regulations of acequias, which have been worked according to the laws and customs of Sonora and the usages of the people of Arizona, shall remain as they were made and used up to this day; and the provisions of this chapter shall be enforced and observed from the day of its publication.

3224. (Sec. 26.) All plants and trees of any description growing on the banks of any acequia shall belong to the owners of the land through which said acequia may run.

3225. (Sec. 27.) Any person owning lands which may include a spring or stream of running water, or owning lands upon a river where there is not population sufficient to form a public acequia, may construct a private acequia for his own uses, subject to his own regulations, provided it does not interfere with the rights of others.

3226. (Sec. 28.) All laws conflicting with the provisions of this chapter are hereby repealed.

[NOTE.—The foregoing chapter is compiled and taken from the Compiled Laws, chapter LV, page 528. There was no legislation upon the subject by the fourteenth legislature (1887), and this chapter remained unchanged.]

CHAPTER 3—*Ditch Crossings.*

[Approved February 7, 1887.]

3227. (Sec. 1.) Any person, corporation or company, owning or using any ditch or canal constructed for the purpose of conveying water, shall construct and maintain suitable crossings wherever said ditch or canal crosses any public highway, or usually traveled road of this territory; said crossing shall be maintained as follows:

From the bottom of the ditch in the roadway there shall be a uniform rise of not more than 1 foot in 3 to the top of the embankment; either side the ditch shall be graveled or macadamized with stone to a depth of not less than 10 inches from the top of one embankment to the other, and the macadamized or paved road across any of said ditches shall not be less than 14 feet wide; provided, that any person or persons, corporation or company may at any of said crossings construct and build a good and substantial bridge to be approved of by the road overseers of the district.

3228. (Sec. 2.) The road overseer of each of the districts in the several counties in this Territory shall have supervision of said crossings, and it shall be his duty to see that the several ditch crossings in his district are constructed and maintained as provided in the preceding section.

3229. (Sec. 3.) For neglect or refusal of any person or persons, corporation or company, whose duty it shall be to construct or maintain such crossings as provided for in section 1, for the period of ten days after being notified in writing by the road overseer of the district in which any such crossing needs construction or repair that such construction or repair is required, such person, corporation or company shall be guilty of a misdemeanor, and upon conviction thereof before a justice of the peace of any such precincts, shall be fined not less than $10 or more than $100 for the first offense; and of not less than $25 nor more than $250, and the costs of prosecution, for each subsequent offense; provided, that whenever such highway or road is constructed, after the construction of such ditch or canal, it shall be the duty of the road overseer of the district to construct and maintain such crossing at the expense of the road fund of the district, and if the same be at any time insufficient, the same shall be paid out of the general fund in the county treasury, to be chargeable to and thereafter collected from such road fund.

3230. (Sec. 4.) All funds collected under the provisions of this act shall be paid into the road fund of the district, wherever such crossings are situated.

3231. (Sec. 5.) This act shall take effect immediately.

[NOTE.—The foregoing chapter is taken from the Compiled Laws, chapter LV, page 541.]

ADDENDA TO NEVADA DIVISION.

STATEMENT OF LYMAN BRIDGES, OF SAN FRANCISCO.

[The following paper has been delayed. It was prepared originally for the Nevada Division, Mr. Bridges being at the time division civil engineer in the U. S. irrigation survey for the Lahontan Basin, which includes Nevada and part of the California Sierras.]

In laying our reclamation works for western Nevada the lakes lying at high altitudes upon the eastern slopes of the Sierras Nevada have to be first considered. Speaking of the physical and hydrographic geography and formation of the basin in which Nevada is situated, this series of lakes, though located in whole or part within the political or State line of California, belong in every natural sense as storage and drainage sources and systems to the eastern basin region. For that reason, then, a good deal of the work of the survey has been done in connection with the idea that these lakes must form the reservoirs from which, in connection with the Truckee Basin, the supply of water needed for the reclamation of the Carson Valley and the Sage Brush Plains around Wadsworth must be drawn.

During July the survey of the basin at Donner Lake has been continued, contours of the lake and its valley two miles east of and including the lake giving an elevation of 20 feet above the present Donner Lake. This will make a reservoir of over 5 square miles, with an everage depth of 40 feet, holding an estimated volume of 5,575,680,000 cubic feet of water in a natural land-locked basin. The elevation is 5,885 feet above sea level.

The outlet of the projected Donner Lake reservoir will be by a high-line canal along the benches on the north side of Truckee to the plateaus north and northeast of the city and to the east of Boca and Verdi, crossing Prosser Creek and the Little Truckee River. There can be selected reservoirs at that point in which we can store water enough to fill Dog Valley. This will ultimately become available for the valleys and plateaus north and east of Reno. A basin map of the Sierras is being prepared. It will show this system.

We have also located a place for a dam across the Truckee River about 1 mile above the Central Pacific depot. This will give a reservoir 3 miles in length along the Truckee Valley. Contours of this basin are being made, and we expect to get a reservoir by the projected dam holding fully 200,000,000 cubic feet of water, as Bear Valley, Squaw Valley, Deep Creek, Pole Creek, and others enter the Truckee River above its location. There can also be a connection from Donner Lake reservoir with this. The outlet from this reservoir will be on the south side of the Truckee River, along the benches and high foot-hills south of Truckee City, around the Marquis plateau and meadows into Marquis Creek, which flows into the Truckee River near Boca, about 10 miles below Truckee. This canal through Truckee and along the hill-sides

may also afford an excellent water-power for mills, etc., for a mile or more before being used on the plateaus, and again entering the Truckee River offer an ample supply for Truckee meadows; or it can be carried by a higher-line canal to and around the Washoe Basin here in western Nevada.

This dam, with the reservoir it will create in the Truckee, taken in connection with Lake Donner, will store, the two together, nearly or quite 6,000,000,000 cubic feet; quite sufficient for the supply of all lands now under ditch or available therefor; as well as the reclamation of at least 1,000,000 acres more. This is now given over to the sage-brush and the few broad-horned steers that feed upon it. A careful study and survey of the other lakes—Independence, Webber, and Eagle—with reservoir sites as found, is also being made by my assistants. Lake Tahoe, by a dam at its outlet near Tahoe City, can readily be raised 8 feet. It has a drainage basin tributary to its supply of at least 5,000 square miles.

In my view of its utilization, Lake Tahoe should be held in reserve—the great storage reservoir which will meet extraordinary needs. Over one-third of its area is within the boundary lines of Nevada. A tunnel has been proposed to lead into the Carson Valley, by which the water thus stored can be drawn from its depths, at least 1,000 feet below its surface. As the site and route have not been fully decided upon, for obvious reasons it will be seen I can not state the location more definitely. We have run three lines across the Sieras between Lake Tahoe and Carson Valley, and have adopted the shortest and best location for a tunnel, which we find to be near the southeast portion of Lake Tahoe and the head of Carson Valley, all in the State of Nevada, locating a tunnel 10 by 10 feet, with a crown of 2 feet in center. The open cut from Lake Tahoe to the entrance of the tunnel will be 4,200 feet; the length of tunnel 17,331 feet, or 3.45 miles, the cut and tunnel having a grade of 2 feet per mile. The exit of the tunnel on the Carson Valley or east side is to be 1,500 feet above the valley.

The output of this tunnel can be carried both north and south along the foot-hills and carried to any portion of the upper Carson Valley, and thence into the Carson River. In addition to the great benefit to be derived from the placing of this water upon the Carson Valley lands, a magnificent water-power can be secured and utilized along the east side of these mountains, and dynamos charged so that this power can be transmitted to Carson and Empire where the Virginia City mills are located, and the water used over again in Douglas, Ormsby, Washoe, Lyon, and Churchill Counties, all of them in Nevada. It is a perfectly feasible and not an expensive project either. A dam will have to be located also at the outlet of Lake Tahoe on the west side at Tahoe City to raise the Lake 8 feet. The inlet to the canal and tunnel is located so as to receive 20 feet depth of water at high-water mark. This will give 200 square miles of surface water 20 feet deep; equal to 111,518,600,000 cubic feet. The lake will never be more than 12 feet lower than the present height. This grand reserve reservoir can be turned either into the Carson or Truckee basins. The elevation is 6,200 feet.

On the 4th of July last, at the chairman's (Senator Stewart) request, I met at Carson with the Senator, the State surveyor-general (Mr. J. E. Jones), and Commissioner H. Springman, of the State board of water and reclamation, as well as some other gentlemen. A conference and exchange of views was held. Many valuable suggestions were obtained pertaining to the water-sheds, water supply, water-courses, locations

for reservoirs and canals on the eastern slope of the Sierras and within the State of Nevada.

The State of Nevada having appropriated $100,000 for water storage, which is immediately available, this committee and the citizens present requested me to locate a reservoir site for them. Commissioner H. Springmayer accompanied me for four days to the head of the Carson Valley, going well up toward the head of the three branches of the Carson River. We found Hope Valley, at the head of the West Fork of the Carson, an admirable location for a large reservoir. By making a dam 150 feet high we could secure a surface area of not less than 5 square miles, with an average depth of 50 feet. This dam we located at the foot of the Carson Valley and at the head of Hope Cañon, which has a granite ledge on both sides. For the first 100 feet in height it has a narrow gorge of 200 feet at bottom and 800 feet in width at top, with rock benches about 500 feet on either side above the first 100 feet. This is a land-locked valley about 5 miles in length, an average of 1 mile in width, 7,658 feet above the sea, and will hold 6,969,600,000 cubic feet of water, with average depth of 50 feet. This reservoir will require two outlets to be cut in rock on both sides, and the water can be then turned into the river below. This is the West Fork of the Carson River. It would conduct the water 6 miles down Hope Cañon to a diverting dam to be located about 1 mile above the mouth of the cañon, where a canal on the left or north side of the river would conduct the amount of water required along the foot-hills at the base of the mountain and north of the cañon at any desired height as far north as Sheridan or Genoa, and distribute it then down the foot-hills and into the valley until it reaches the West Fork of the Carson River. From this same diverting dam, 1 mile above the mouth of Hope Cañon, on its right bank, another canal can be constructed along the right bank of the West Fork of the Carson River, with a sufficient grade to conduct any portion of this water from the Hope Valley Reservoir across Diamond Valley 2 miles in length; this is located at the foot of Hope Cañon, with an elevation of 5,481 feet, then through Dutch Valley, with an elevation of 5,277 feet, and this also about 2 miles in length; thence into Long Valley, which has an elevation of 5,078 feet above the sea and about 200 feet above the head of Carson Valley. There are already three ditches running from Hope Cañon and conveying water through Diamond Valley to Dutch Valley, whose natural drainage is into Long Valley. One of these ditches can be enlarged into a canal, and the flood and natural water from the West Fork of the Carson can be secured to Long Valley, which is a good, natural, safe location for a grand receiving reservoir; all outside of any river channel.

With a dam 100 feet in height at a narrow neck of Long Valley about 1 mile above the head of Carson Valley nearly or quite 4 square miles of surface water with an average depth of 50 feet can be obtained. This will give 5,625,680,000 cubic feet of water for distribution by a canal on the east side of the Carson Valley, which will supply not only the Empire Mills, but also all that the 100,000 acres of land on the east side of the Carson River (that now has no water for irrigation) may require. A canal from the left side of this dam out on the benches at the head of the Carson Valley may be supplied from this same source. The east or main fork of the Carson River runs almost parallel with Long Valley for the 3 miles east before debouching into the Carson Valley proper. At Horse Shoe Bend, a point about 2 miles from its mouth, there is a narrow saddle ridge, where with an overflow dam across the East Fork or main river can be turned through a tunnel or cut of about 1,000

feet in length. This will turn the water through a 10 by 10 feet tunnel or cut 10 feet wide at bottom and with its slopes of 1 to 1.

We have found and located a number of other sites. Pleasant Valley, on the Middle Fork of the Carson, in Alpine County, Cal., 12 miles south of Hope Valley, which is about 3 miles in length and 1 mile in width, can be made from 40 to 50 feet in depth as a reservoir, with a water-shed of 50 square miles, and it has good rocky flanks at the lower end of the valley. This location is 3 miles above Markleville, Cal., and in it can be stored 3,345,408,000 cubic feet of water. Below this reservoir and above Markleville are the waters from Burnside Lake, Hot Springs Creek, Charity Valley, and other mountain creeks. At Markleville, 18 miles above Long Valley, the East and Middle Forks of the Carson unite, thus making the East Fork the main Carson River, so that by the diversion of the East Fork at Horse Shoe Bend Long Valley can receive the water of all the branches of the Carson to its full or maximum capacity. Twelve miles above the junction of the Main and East Forks of the Carson River Silver Creek joins the East Fork. Five miles farther southeast Wolf Creek empties into the East Fork. One mile above the mouth of Wolf Creek is a meadow where from 1 to 2 square miles surface of water can be stored with a depth of 40 feet. Two miles above Wolf Creek, at Silver King Valley, on the East Fork of the Carson, another reservoir can be located with a water surface of 2 square miles. Now, all the above-named reservoir sites in Alpine County are above 6,000 feet elevation. Other sites have been examined but found impracticable. The water-shed for the Carson River and its branches is fully 1,000 square miles.

The commission which the State of Nevada authorized to construct reservoirs and canals has made a formal request that I should make a plan and locate their reservoirs and canals, which I agreed to do. They promised to proceed with their work without delay. This reservoir at Long Valley, the one that they desire to use as the State reservoir, you will observe, is the grand receiving reservoir between the forks of the Carson River, and any dams built above by the United States or otherwise will be feeders for this grand receiving reservoir owned by the State of Nevada. As to other reclaimable areas I desire to say that at Wadsworth, Nev., 34 miles below Reno, the Truckee River turns north and sinks into Pyramid Lake, 15 miles from Wadsworth. At a point on the Truckee 5 miles west of Wadsworth an admirable location for a diverting dam was found, which can be built of stone in rocky bluffs 116 feet higher than the water surface at the Wadsworth bridge. A dam and reservoir has also been located there, and our men are running levels for canals on either side of said river to conduct the water out on the plateaus and benches north, east, northeast, and southeast from Wadsworth. The bridge, which is now 30 feet high, can be filled up, and a 10 by 10 feet outlet and canal put in on each end of the bridge to guard against any possible flood or overflow or accident. This water can be extended along the benches if required.

I have made many inquiries and obtained memoranda in as many counties and districts of the eastern slope of California and of the State of Nevada as I have had opportunity. From the information thus obtained I can safely state that by the storing of the flood waters at the head of the Carson and Truckee Basins and other water-sheds along the eastern slopes of the Sierras at least 500,000 acres of fertile lands in California and not less than 2,500,000 acres of good arable lands in Western Nevada can be reclaimed and cultivated; all this in addition to the area now under cultivation. It will be seen that the aggregate

amount of water in the reservoirs already selected is estimated at 133,229,968,000 cubic feet of water, and from the best information obtainable the reservoir can be filled annually from natural water-sheds. The demand for water in this State is at the rate of 1 cubic inch per acre, and is much in excess of that generally required in the State of California. The estimated amount for the reservoirs now located will furnish an acre-foot for 3,000,000 acres of land. I am convinced that we shall be able to find reservoir-sites that will hold an amount sufficient for another 2,000,000 acres of land; that is, having an acre-foot of water for each acre. This will make 5,000,000 acres that can be reclaimed in this division by the storage of water sufficient therefor. The waters of the Truckee and Carson and auxiliary springs have been carefully gauged daily, giving the velocity and quantity and discharge in cubic feet per second. A sample of the gauging of the Truckee River at Essex above the ditches and canals is as follows:

	Name.	Mean velocity.	Discharge.
			Cubic feet.
May 20	Truckee at Essex	2,630	2,336.67
22	....do	2,767	2,511.84
28	....do	1,983	1,716.25
June 20	....do	358,549	350.49
May 22	Dog Creek		6.89
24	Prosser Creek		312.52
June 21	....do		64.33

In concluding this imperfect statement, I wish to say that there is reason to believe that we can gain as much in the Humboldt and also in the Owyhee Valley region in Northern Nevada as I have estimated for the eastern California, Sierras, and western Nevada. Land under water will be worth from $10 to $30 per acre. It is now worth 50 cents or $1. The cost will certainly not exceed $1 in $4 of the increased value I have named.

STATEMENT OF CHARLES W. IRISH (UNITED STATES SURVEYOR-GENERAL), OF RENO, NEV.

Under date of January 6, 1889, the surveyor-general of Nevada writes:

As to the improvement of the arid lands of the State through the means of water stored by reservoirs and distributed upon said lands by means of some system of irrigation conduits, the first question which I come to consider is the amount of annual rain-fall, which, of course, includes the snow-fall. Of the first the State does not receive enough rain per year in all parts to insure an agricultural crop, for the average, including the snow-fall, is, I think, not far from 8½ inches.

It is concluded that about twice this amount is absolutely necessary for the purpose, and such amount indicates a precarious region for the farmer; its efficacy depending very much upon the kind of subsoil which receives it.

I think that the rain fall proper can not overgo about 5 or 6 inches per year for the whole State, which, if I am correct, leaves the amount of water derived from the snow-fall to be about 2½ to 3½ inches. This estimate applies only to the valleys, for the reason that only in them have systematic observations been taken. It is, as will be seen further on, vastly different upon the mountains. It is the snow-fall which is of greatest value to the State, for the reason that, lodging upon the mountain tops, sides, and cañons, it becomes so much water stored away for future use through the preserving coolness of those elevated regions, from which it is let down by degrees to the plains below at the season when most needed by the farmer.

As to the observed amount of annual rain-fall as reported for this State, I must say that it, in my opinion, must fall far short of the truth, for the reason that all the observing stations are located upon the plains and valleys at the foot of the mountains, *where* the ganges catch but a very small part of the snow-fall, the important factor *in this* case, and also do not catch all of the rain.

42°
41°
A
40

I have made experiments for the purpose of determining the proportion in inches of water to be derived from freshly-fallen snow in this State, and find that it is 1 inch of water from 11 inches in depth of snow; this is the result of many averages.

Now it is rare indeed to have more than a few inches of snow to fall in the valleys, and a fall of 25 inches is rare indeed, but on the mountains it is quite different; there the snow falls to great depths.

The great snow-catchers of this region are the Sierra Nevada Mountains.

I have been at great pains to discover, in the absence of definite measurements, the depth to which the winter snows fall upon these mountains, and find that the average is not far from 18 feet over all their surface above 6,000 feet altitude.

It is sometimes as much as twice this amount and at times less, but it is safe to count upon about this quantity in ordinary seasons. This amount of snow will, when melted, give 19 inches of water over the area upon which it is lodged.

In the storing capacity of this giant mountain range is seen the great value it is to the people of the state. The more valuable for the reason that the region immediately eastward of it is about the driest in the State, and would be, without the vivifying stores of winter storms, retained by these grand old mountains, totally uninhabitable and useless to man.

All the mountain chains of the State are more or less nearly parallel with the Sierra Nevadas, and they in succession eastward, from this the northern range, are known by local names, as shown upon map (number 1) accompanying.

Upon said map I have represented the Sierra Nevadas from A to B, the great bulk of these mountains lying without the State, in California, but all the drainage of their eastern slopes falling within Nevada, giving rise to the Truckee, Carson, and Walker Rivers.

The next range eastward is shown at L, M, and is properly called the "Virginia Range," from the fact that Virginia City, the most important mining center in the State, is located upon it just under its highest peak, Mt. Davidson.

The Multiple range, shown at C to D, is known as "The Toy-ah-be." In altitude, and linear extent it rivals the Sierra Nevadas. The Toyahbe Mountains are the backbone of the State.

From E to F is the "Diamond Range," and from G to H is the "Ruby Range," an apparent branch of the former. The Rubies are, throughout their extent, very high mountains.

Lastly from I to K is the "Schell Creek Range." Between these principal lines are many lesser ranges, branches of, or lying parallel to, the main ranges already described.

I have not attempted to describe these lesser ranges nor show them upon the map. From careful examination of all sources of information I estimate that the surface area of Nevada's mountains (I mean as seen in plan) is 52,000 square miles, and that of this area 18,000 square miles catch and hold snow the year around.

Of the 18,000 miles of snow-catching area, all that portion which is in altitude above 6,000 feet will receive in average winters from 4 feet to 26 feet of snow, which will, I estimate, give an average of 16 inches of water, and this average, in my judgment, will hold good for the whole State, for the reason that the estimate does not include the large catchment area of the eastern slope of the Sierra Nevadas, where the yearly average depth of snow-fall is much greater, all of which drains into Nevada.

But all the snow caught by Nevada's mountains does not stay all the year upon their tops and sides, for the warm winds, which by their natural direction in proceeding from the equatorial regions toward the great easterly circulating belt along the forty-second parallel of latitude, fall into the valleys of Nevada and follow them throughout the extent of the State in a south to north direction and eat away the snow from all the subsidiary ranges, thus causing streams of water to run down the cañons from early spring until about the end of July, by which time nearly all of the snow which lodged below 6,000 feet altitude is melted away and the water from it has run down to the plains below, and has been absorbed by the soil or can be seen collected in a thousand shallow lakes of greater or less extent—natural reservoirs. With proper engineering, I believe that 90 per cent. of this, the first fruits of the winter storms, can be saved for the production of what are called here second crops, which in most cases will be limited to the foot-hills along the bases of the mountains, and matured in the months of September and October, by which time the greater part of this store of water will become exhausted, to be again replenished the succeeding spring. The remainder of the snow, which from its altitude is above the reach of the warm air currents spoken of, melts very slowly and much of it remains from year to year.

Map No. 2 is intended to give an idea of the distribution of the rain-fall throughout the valley portion of the State. The results as shown are from exact observations, and do not include the mountain snow-fall. It is seen from this map that the lowest portions of the State are both the driest and warmest, and, singular as it must appear to those who have but little understanding of such matters, these very dry regions are now the most fruitful; as, for example, the region from Reno and Virginia City

eastward towards Austin across the "Sink of the Carson," and from Wellington and Hawthorne, by way of Lovelocks, to Winnemucca; also across the southern parts of the State, below Candelaria and Pioche.

The secret of this is in the fact that for the northerly region mentioned the drainage of the eastern slope of the Sierra Nevadas comes down to and covers all the "Sink of the Carson" region, from Pyramid Lake to Walker Lake, depositing an immensity of water over and above the yearly waste by evaporation and constant percolation, and for the further reason that the Humboldt River brings an immense quantity of water from the region bounded by "Burner's Ranch," Elko, Tuscarora, and Paradise Valley, down to its "sink," now called Humboldt Lake. In the southern region mentioned the reason for fruitfulness is in the fact that there is no winter season there. Winter being replaced by a season of light rains, during which the crops are put in, and the light rain-fall, aided by an immense underground supply of moisture, is sufficient to produce and ripen the crops before the hot and very dry summer sets in. When a water supply is available for the purpose, a continuous yearly round of crops is produced almost without exception.

The source of the great under surface flow of the regions included in Nye and Lincoln Counties is seen in the great difference of altitude between the northern and southern portions of the State,* which amounts to about 3,800 feet, whereby all the water entering the strata of the northern portion is carried down a grade of about feet per mile, to this region.

The substantial evidence of this is seen in the many strong flowing springs to be found in the two counties mentioned. Of three of these springs I have a close approximation to their capacity of flow for a period of twenty-four hours. They are all in the same vicinity. The one highest upon the mountain gave 472 cubic feet; the next in order lower down, 1,744, and the lower one, quite down to the base of the mountain, 3,860 cubic feet per twenty-four hours. From all that I have myself seen of the region in question I feel that it is the only part of the State which can be relied on to furnish a certain and continual supply of artesian water.

(Referring to Map No. 2.) In the northeast quarter is a region which I have marked as "Rain-fall unknown." I am sure that throughout this part of the State, from Fort McDermitt southeasterly, is the future wheat region of Nevada. I conclude this from my personal observation of its climate and soil and its natural vegetation. I feel certain that over a very large proportion of the region indicated wheat can be grown under about the same conditions as it is produced in northwestern Minnesota and northeastern Dakota.

This subject brings me to Map No. 3, upon which I have endeavored to show the regions of the State in which the crops there indicated can be grown with a certainty and success.

The climate of the region marked A is the least variable of any part of the State; the winters never very cold nor the summers hot. It contains the largest area of veritable desert land in the State, comprised in the Black Rock and Smoke Creek Deserts, areas which produce no vegetation whatever. I have verified the statement as to its range of crop products.

I have heretofore stated as to the region D. Its climate is much like that of western Minnesota, and a bountiful snow-fall, with very rare exceptions, is assured. Soil, climate, and snow-fall all combine to make it the wheat region of the State. Its average altitude is considerable, and having no deep valleys, its climate is the coldest of all the State; hence the snows are more lasting upon its mountains, and water from that source is plentiful. It contains the highest mountains to be found within the State.

The central region B contains high mountain regions and deep wide valleys, with a bountiful mountain snow-fall; hence water is very plentiful in spring and summer months, as evidenced in the broad shallow lakes to be found in all the valleys in the mid-summer season. Its climate is mild, and Indian corn can be raised within it.

Experiment on a large scale has fully proven the statements on the map as to the variety of crops to be successfully raised within it. Its western portions, bordering on the region known as the Colorado Desert, are very dry and hot.

The region marked C has a greater range of productiveness than any other part of the State. Its climate much resembles that of the Gulf States, more particularly that of southern Texas, not subject, however, to such great variations of temperature. Its winters are warm and spring-like, and are the seeding season, and about all the rain-fall of the year comes down at this season and is small in amount. Here the semi-tropical fruits, which are produced in southern California, can be successfully cultivated, to which can be added cotton and sugar-cane. Thus herein, wherever water can be had by impounding or through artesian pressure, all the agricultural products of the middle Gulf States can be grown, and much more besides.

Cotton and Indian corn were produced in this and surrounding regions in pre-historic times, as I have proven by the discovery of corn-cobs among the relics of an-

*See Map No. 1.

cient dwelling places and of cotton packed in funeral urns along with the bones of the dead and also made into twine and coarse thread and woven into fabrics resembling very coarse blanket stuff. I am able to supply you with a small quantity of the cotton fiber which I procured from one of the ancient burial places west of the Colorado River near to the head of the "Vegas Wash." The urn in which this cotton was found contained human bones, and the urn, with its contents tightly packed within it, was closed with a lid, which was closely sealed with a resinous substance, thus securing it from the action of the air. I found other urns filled in the same manner but not sealed. The cotton which they contained was only slightly stained. As evidence of the antiquity of this relic of ancient agricultural art I will state that the jar from which it was procured was placed in a cave in a mountain side and with several others embedded in a smooth layer of adobe mortar, in which were impressions of the feet of those who made the deposit, tracks of barefooted man. The cave, after its use by man, became the habitation of bats, and they occupying it long enough to deposit manure to the depth of 3½ feet over these relics, forsook the cave, and, when I was there, evidently had not inhabited it for a long time.

I saw enough other evidence, besides the corn-cobs and this flock cotton, to lead me to believe that the southern portion of Nevada had, in times long since passed, been inhabited by a nation of farmers, who extensively tilled the soil, and that they did this by a system of reservoirs and irrigating ditches leading therefrom.

For further testimony as to the fruitfulness of Nevada soil, I have the honor to refer you to my annual report to the Commissioner of the General Land Office and accompanying letters from some of the most experienced of her citizens relating to this subject, dated July, 1889.

I am certain that Nevada can and will produce abundantly all of the crops which are raised in the region ranging in climate from Minnesota to Florida, together with all that flourish in and enrich southern California. The results stated above and as shown by the maps accompanying are not speculations at all, but the results of observation and personal examination; and while they are in a measure approximate, they are to a very great extent reliable.

I have been at some pains to state the amount of water in average seasons upon the surface of Nevada; I will in conclusion now state its quantity as far as the mountainous portions are concerned.

To the 16 inches stored above the 6,000-foot elevation should be added that which, falling below the 6,000-foot melts and runs down in the spring and early summer. The average depth of this snow is about 5½ feet, and I estimate its quantity of water from my average found for snow freshly fallen, viz, 1 inch of water to 11 inches of snow.

I think that it can be safely estimated that 9,000 square miles of mountainous surface will catch this amount of snow in average winters, thus giving 6 inches of water; this added to the amount falling upon the higher altitudes gives 22 inches of water, the greater part of which can be, by careful planning, made available for irrigation purposes.

There is not less than 4,800 square miles of the Sierra Nevada Mountains which shed water into Nevada. Of this area 250 square miles store annually 14 inches of water; 560 square miles store annually 19 inches of water; 1,330 square miles store annually 36 inches of water. All of which that is not lost by evaporation and percolation comes down into Nevada, giving rise to the Truckee, Carson and Walker Rivers. The remaining 2,660 square miles giverise toonly seasonal streams, which dry away with the summer heats.

I estimate the agricultural lands of Nevada at 21,000 square miles. This area will, I believe, be increased in the future by the addition of many square miles of foot-hills now classed as mountains. Be that as it may, the water supply of Nevada, as I have outlined, is sufficient to furnish each square mile of agricultural land in the State with 42 inches of water per annum.

As it is not possible to reach and improve all the agricultural lands of the State by irrigation from the mountains, it is seen that it is possible to supply much of such lands within reach with more than 42 inches per year; that quantity of itself being equivalent to a bounteous rain-fall in other regions.

I have for the past year carried on a series of experiments upon the amount of evaporation at this place, the town of Reno. I found the maximum for twenty-four hours for the day endng August 2, 1889, to be seventy-two one-hundreths of an inch. For the year 1889 it was as follows:

	Inches.		Inches.
January	1.94	August	16.21
February	2.13	September	13.91
March	3.91	October	9.99
April	4.53	November	3.03
May	11.26	December	1.18
June	14.15		
July	17.76	Total	100.00

Eight feet and four inches for the year 1889 was considered the driest and warmest which has been experienced since the settlement of the country.

The spring and early summer of 1889 were especially dry seasons. I am inclined to believe that 1889 will for a long time stand as the maximum dry year for Nevada. In my opinion the evaporation is considerably greater for the central and southern portions of the State. From all that I can gather it was about 19 per cent. greater in those portions of the State for the year 1889 than here in Reno.

In order to give you an idea of the substantial and permanent nature of our water supply, and the consequent reliability of it if properly stored, and being stored, that it can be depended upon to tide the farmers using it over a number of dry seasons, I desire to call your attention to the water-shed of the Truckee River. I estimate it at 560 square miles, with an annual average of 14 inches of water stored in the shape of snow. The Truckee takes its rise in Lakes Tahoe and Donner and numerous mountain streams. The river, leaving Lake Tahoe, makes its way through a deep gorge in the heart of the Sierras, and emerging from them on their eastern face runs its course easterly for 12 miles across the "Truckee Meadows," and continuing that course cuts the "Virginia Range," traversing it for 21 miles, at the town of Wadsworth changing its course to north. It in 17 miles more falls into either of two large lakes.

Pyramid Lake is the larger and deeper of the two. The other lake is called Winnemucca Lake by the whites, and Mud Lake by the Pah-Ute Indians.

The river channel divides at a point 2 miles from the former and 5 miles from the latter. Now it has so happened that, by means of drift-wood and from other causes, one of these channels gets choked up, with the result that all of the water is shut off from one lake and turned into the other. The diverted flow will continue then for a longer or shorter time, lifting the surface of the receiving lake much above that of the other. This is seen in the many, and various, water marks along their shores.

Pyramid Lake is about 1,700 feet deep. Mud Lake is shallow, being, as far as I have been able to sound it, only 65 to 70 feet deep. From its shallowness it at times goes dry; but this happens only at long intervals of time.

I have taken great pains to ascertain the facts, and find that about fifty years ago it was entirely dry, so that the Indians used its bed for a road from one end to the other. There are Indians now living who remember having traveled along its bed many times.

In 1844, at the time of General Fremont's first trip through this region, it was slowly filling, by reason of a great dam of brush and cotton-wood timber, which was pushed into the Pyramid Lake channel by a great freshet in the river some time before that date. The filling has continued to the present time; so that now, as before stated, the lake is about 70 feet deep, and completely covers all its bed. The length of this lake is 28 miles, and its average width 6½ miles. Thus it is seen that in fifty years' time the Truckee River drainage has stored in Mud Lake, 2.4 cubic miles of water. But this is not all of its storage capacity, for within the fifty years spoken of it has again and again filled up Pyramid Lake, a much larger body of water, through a rise and fall of at least 25 feet; so that I am disposed to place the storage by the Truckee River for a period of fifty years in these two lakes at not less than 5 cubic miles of water, over and above all the losses by evaporation and percolation. This would be at the rate of 14,719,795,200 cubic feet per annum, which sum is the result over and above all losses by evaporation, percolation, and used by irrigation for the past twenty to fifty years. This amount of water would cover a square mile 7,795 feet deep each year if diverted from the lakes and so used.

That irrigable lands may be taken by settlers and put under improvement, in this State, with proper facility and with safety to the appropriators. The land laws require a radical revision to that end. I am sure that a settler on the public lands here will require, at an average, three years' time in which to so improve and irrigate his selection, that he can take his family upon it to permanently reside. The homestead law should be so changed as to allow a selection to be made, and at least three years' labor upon it, to get water to it, before requiring a permanent family residence thereon, and also requiring that at the least, labor to the value of $5 per acre of land claimed, be done each year to that end, and that the land be fully improved, and under crop on the making of final proof, which change in the laws would accomplish much.

The proper safe-guards should be provided by law, to prevent the labor of the settler finally going into the hands of land sharks.

There is much valuable public land to be found in the mountain cañons, where very fruitful farms can be made and cultivated through aid of the early melting snows, which can not now be taken under the present land laws.

The legal requirement that homesteaders and pre-emptors shall take their lands in a compact body approximating a square in shape is in the way. In many cañons in Nevada's Mountains, farms of 160 acres can be made, but of very irregular shape, and *will be* as much as 2 or 3 miles long. The land laws should provide for the improve-

42°

41°

40°

ment of such cañon lands, for they otherwise will go to waste. I feel that there will be large bodies of land so situated, as that their improvement will be beyond individual effort; these can only be improved through the organized effort of a colony, hence, the land laws should provide for the colonization of such lands.

In conclusion, I have to say that any system of irrigation which does not provide for the impounding of the water in any useful quantity, large or small, will be useless to the people of this State.

Such plan should provide for the using of the water wherever found, in reservoirs, or by other means, and in quantities from ponds 20 acres in extent, and 5 feet deep, up to the largest areas which can be covered, and with dams to the highest limit, consistent with safety.

LAKES TAHOE AND DONNER FOR IRRIGATION PURPOSES.

STATEMENTS OF FRANCIS G. NEWLANDS AND R. L. FULTON, OF RENO, NEV.

The following papers having been forwarded to the committee by the Nevada State Board of Trade, it is ordered that they be inserted with the testimony taken in connection with Nevada:

PROPOSITIONS FOR THE USE OF LAKES TAHOE AND DONNER, MADE BY FRANCIS G. NEWLANDS.

Shortly after my coming to Nevada the prevailing subject of discussion in Reno was water storage, and the general sentiment was expressed that the Government only was able to give the necessary relief and aid. My judgment was that this community would have to take the matter in its own hands, first, because the Government is proverbially slow in such matters; second, because the political views of one of the national parties are opposed to the Government undertaking enterprises which can be undertaken by private capital, and that this sentiment, co-operating with the ignorance in the East of Western wants, might defeat measures for relief; and third, because I had reason to believe that most of the storage sites were out of the ownership of the Government and in the ownership of private individuals.

As to the State board of reclamation organized under the act of the last legislature, I found upon conference with its members that they were hampered with doubts as to their powers, as well as the question whether a proposed enterprise could be completed within the proposed limits of the appropriation made ($100,000), and also difficulties arising from the supposed onerous nature of the rates exacted by the law for the use of water.

I said that I was disposed to spend some time and money in securing a practical solution of the difficulty, and endeavored to ascertain the facts with reference to the title and ownership of the various reservoir sites on the Truckee. I was then brought in communication with Mr. Robert Fulton, the land agent of the Central Pacific, who has a greater familiarity with the topography of the country than any man I have met. The result of our investigations was that we ascertained that the outlet of Donner Lake was in the possession of Mr. Kruger, of the Truckee Lumber Company, and that he had recently constructed a dam there about 6 feet in height. We found the outlet of Lake Tahoe, consisting of 118 acres, was in the ownership and possession of the Boom Company, the principal stockholders of which were Leland Stanford, C. P. Huntington, the estate of Charles Crocker, and other persons interested in the Central Pacific Railroad Company. We immediately commenced negotiations with a view to the purchasing of these outlets, I agreeing that I would advance the money to perfect the dams, store the water, and turn over the completed works either to the State of Nevada or to the county of Washoe, or to the united ditch-owners on the Truckee, as might be deemed advisable. I communicated with Mr. Charles F. Crocker on the subject shortly prior to his departure for the East, by letter, Mr. Fulton taking the letter, and having also a personal interview with Mr. Crocker.

The following is a copy of the letter addressed by me to Mr. Crocker:

CARSON CITY, NEV., *September* 26, 1889.

MY DEAR CROCKER: You doubtless know that "irrigation" is the absorbing question in Nevada at present and that surveys have been and are being made by the United States Government of the various sources of water supply, with a view to the establishment of reservoirs for the storage of water, so that the supply may be continuous—not as at present, too abundant during the spring and early summer, when

the snow is melting, and scanty when it is needed for the maturity of crops and for the second and third crops of alfalfa and other grasses.

The storage project to which I call your attention in this communication is that of the Truckee River, and I propose to show you how the Central Pacific Railroad, or the men who are interested in it, can greatly benefit this State and its people, and at the same time largely increase the revenue of the railroad. I shall probably give you some information of which you are already possessed, but it is necessary to a connected statement. The Truckee River takes its source in Lake Tahoe on the eastern side of the Sierras and flows past the town of Truckee, Cal., and the towns of Verdi, Reno, and Wadsworth, in Nevada, a distance of 97 miles, emptying into Pyramid and Winnemucca Lakes. It obtains about one-fourth of its flow from Lake Tahoe, the other three-fourths coming from water-sheds which empty into the Truckee below Tahoe, such as the Little Truckee, Prosser Creek, and the outlets of Donner, Independence, and other small lakes.

The sources of this river are almost entirely in California, but they can be of no benefit to it so far as irrigation is concerned, for the reason that the California lands adjacent to it are on the eastern slopes of the Sierra Nevadas, and are mountainous and precipitous. The water is not utilized for irrigation until the Nevada line is reached, and from that line to Wadsworth a strip of country 50 or 60 miles in length and from 2 to 15 miles in width is transformed from a desert into a fertile country, equalling in productiveness and surpassing in climate any irrigated district in California that I know of, except the San Gabriel Valley, in Los Angeles County. Within the reach of the Truckee River, by ditches which have been surveyed, lie 400,000 or 500,000 acres of land superior to any that has yet been irrigated. The only thing that prevents this land from being made of great value to the State and a great source of revenue to the Central Pacific, is the scarcity of water during the months of July, August, and September, when the crops are maturing. When the water is most needed it is scarce, and when it is least needed it is abundant and over flowing. During March, April, May, and June the snows melt and fill the river with an overflowing stream, of which a very small proportion is utilized, the balance pouring into Pyramid and Winnemucca Lakes, which lie in the sink of the desert and have no outlet. Some idea of the magnitude of this volume can be formed when I tell you that the area of these two lakes is (as I am informed) about 600 square miles, or over 360,000 acres, and that the depth of Pyramid Lake is in some places 160 feet, and in others even more. If this water to the depth of 4 feet could be led by ditches over fertile land, it would put under cultivation over 500,000 acres. As it is, the water rushes to these lakes and can not be utilized, for the lakes are below the level of the adjoining lands. In July, August, and September, when the water is most needed, the river runs almost dry, and the farmers of the 50,000 or 60,000 acres now under irrigation, fearful lest the drought may wither their crops, are engaged in a continual fight for the scanty supply that does come down.

Much has been expected from the United States Government, but the people are beginning to realize that it moves slowly and that little will be done beyond the ascertainment and survey of reservoirs, the enterprises themselves being left to private capital. We have already ascertained all that can be learned about the sources of the Truckee River. We know that a dam costing $10,000 can be constructed at the outlet of Lake Tahoe, which if raised only 10 feet high will store for the period of scanty supply a body of water in addition to that at present in the lake covering 175 square miles and 10 feet in depth, all of which, except that drunk up by the sun, can be utilized in the period of greatest scarcity, and capable of irrigating millions of acres, in connection with the utilization of the water which flows from other water-sheds into the Truckee during the flood season.

The title of the land on which this dam must rest is not in the Government. If it were the solution would be simple. But I was glad to find that it was in the name either of your father or yourself and that a dam was at present upon it, and that in some way it was in the possession of a boom company organized under the laws of California for the booming of logs down the Truckee River, and that the stockholders of this company were the gentlemen interested in the Central Pacific Company—Governor Stanford, C. P. Huntington, yourself, W. E. Brown, and others. I say that I was glad to hear this for I felt satisfied that the public spirit as well as the business policy of these gentlemen would prompt them in some way to utilize this land to the advantage of Nevada and its people and the consequent profit of the railroad in which they are interested and which traverses from one end to the other the State of whose products and supplies it is almost the only carrier.

Something can be done immediately in behalf of this community, and I appeal to you to do it before your departure—and that is to take measures to bring some of the gentlemen interested in your railroad in communication with a committee of the people of Reno on this subject. And I suggest also that orders be given to keep the gates of the present dam shut down during the coming winter and spring so that the *water of the* lake can be stored, and if the present dam is insufficient that a new one

be immediately constructed. If necessary I will undertake to see that the money is raised for this purpose. All this can, I think, be done immediately. Measures for the more complete utilization of the waters can be devised hereafter when you are more at leisure. The people along the Truckee River will, I am sure, form a corporation to purchase the land at the outlet of Lake Tahoe at a reasonable price; or, if you would like to enter into an irrigation enterprise on a large scale, I suggest that you give the opportunity to the people of this State to subscribe to it.

I think that with the unremunerative rates which the competition of the Canadian Pacific and other trans-continental railroads has caused, it will be sound business policy to build up a country through which so much of your road passes and over which you have no competitors. I am sure that this can be done, and the best evidence of the sincerity of my opinion is that I am disposed to invest largely the funds of the estate of which I am trustee in a State from which it has received so much of its income. * * *

FRANCIS G. NEWLANDS.

Mr. Crocker was very much hurried making preparations for departure for the East, but expressed himself favorably in general terms to the immediate utilization of Lake Tahoe, and wished Mr. Fulton to make a proposition which could be submitted to the directors of the Boom Company. Mr. Fulton did not think it advisable to make a proposition then, as Mr. Crocker was hurried and had not time to entertain it. Subsequently I sent a copy of this letter to Senator Stanford, who was then at Sisson Springs, asking his immediate consideration of the subject upon his return to San Francisco. Meanwhile Senator Stewart arrived in Reno upon his return from the labors of the Irrigation Commission. Mr. Fulton and myself had an interview with him and enlisted his active co-operation. He proceeded immediately to San Francisco and had a conference with Governor Stanford and secured an opportunity for a conference with a committee of citizens of Reno, consisting of Messrs. Fulton, Martin, Wheeler, Foley, and Mayberry.

Shortly after Senator Stewart's arrival in San Francisco he sent me the following letter:

SAN FRANCISCO, *October* 7, 1889.

MY DEAR NEWLANDS: I have just had an interview with Governor Stanford in regard to the Lake Tahoe matter. He says that he will make any fair arrangement whereby the people in Nevada shall have a right to use so much of the waters of Lake Tahoe as they can appropriate. He wants the arrangement made, however, so that the people will have the benefit of it, and that it shall not be monopolized by a few individuals.

I saw Mr. Fulton after my interview with the governor, and told him that he had better have the committee come down, and we would then call on the governor and try to perfect an arrangement. The governor seemed to care more to have the water economically used than the money to be paid for the right. If ready money is necessary to perfect the arrangement—and it probably will—are you willing to advance it and hold the title for the use of the people of Washoe County or of the State of Nevada? I do not know exactly what form the case will take or what contract Governor Stanford will want, but I will do what I can to put it in the best shape.

Yours, very truly,

WM. M. STEWART.

FRANCIS G. NEWLANDS, Esq.,
Carson City, Nev.

I immediately replied as follows:

CARSON, NEV., *October* 9, 1889.

MY DEAR SENATOR: I received your letter of October 7 to-day and immediately sent the following telegram:

CARSON, *October* 9, 1889.

Senator WILLIAM M. STEWART, *Palace Hotel, San Francisco:*

All my efforts in the matter of irrigation have been for the benefit of the State of Nevada and not for personal profit. Will advance any money necessary to perfect arrangements and will start immediately to work upon necessary dams, holding the title for the people of Washoe County or State of Nevada subject to payment of my advances and per cent. interest. Telegraph me Fulton's address and keep me fully advised.

F. G. NEWLANDS.

I presume this is sufficiently explicit.

I have often observed the inability of communities to deal with practical questions. The business man can often solve in a few hours what it takes a community months and years to determine upon. When I first came to Nevada I was surprised to find how little accurate knowledge there was with reference to the subject of irrigation, and particularly of storage. In my talks with individuals I have been in-

sisting that it would not do to wait for the Government to move, as it would be too slow and possibly would not move at all, and that the only course to pursue was for the community to act on business principles, as any individual would do, ascertain the facts, and then act quickly. But the old adage, "What's everybody's business is nobody's business," has proved true. The people along the Truckee River have struggled along for years without solving the question, which was of comparatively easy solution. So, after ascertaining the facts from Mr. Fulton, I determined to negotiate for all the available dam sites in the headwaters of Truckee River. I have secured that of Lake Donner, and wish to secure that of Lake Tahoe. I don't propose to wait for the community as to the construction of dams; I shall build them immediately. They will not be expensive. I shall then hold the property for the county of Washoe or the State of Nevada, as may be determined to be best, and shall turn them over in complete condition for storage upon reimbursement to me of my expenditures with 6 per cent. interest.

I propose to undertake the construction of the dams for the reason that otherwise time will be lost. The county of Washoe has no power to undertake such a construction, and the act of the legislature appropriating $100,000 is coupled with such onerous conditions as to rates for water as to make it undesirable to use in that agency.

I know you will do what you can to expedite matters. I am very anxious to get to work immediately upon these dams and hope there will be no delay.

I am glad that Senator Stanford has the disposition of this matter. I knew that his generous spirit would lead him to act with reference to it with an eye for the benefit of this community.

Very sincerely, yours,

FRANCIS G. NEWLANDS.

Meanwhile, Senator Stewart and Mr. Fulton telegraphed to the committee to come to San Francisco and hold a conference with Governor Stanford. At this conference Senator Stanford was very cautious; he did not express himself so favorably as to immediate action as he did in previous interviews with Senator Stewart. He expressed the general view that nature had adapted this lake to the use of the agricultural community on the banks of the Truckee River, but that he was desirous of moving cautiously, so that whatever might be done would be not to advance any monopoly or speculative interest, but the people of that community. The committee retired somewhat discouraged, fearing that excessive caution might delay the great enterprise and retard the proper utilization of the waters of Tahoe.

Shortly after Senator Stewart came to Carson and told me the result of further interviews with Senator Stanford; and also told me that he thought that Senator Stanford would turn over the outlet of Lake Tahoe for the benefit of the people of the State, provided the waters would not fall into the hands of speculators or be monopolized by existing ditches, and provided it could be done in such a way as to insure to the people generally the benefit of the enterprise.

Senator Stewart's idea was to have the State reserve large tracts of land in the vicinity of the Truckee River, to which the waters stored in Lake Tahoe and the storage reservoirs could be applied; then to have these storage reservoirs put in the hands of the State reclamation commission, of which Senator Evan Williams is chairman; then to connect the water with the land, and then sell out these tracts to colonies in small parcels of from 20 to 40 acres each, his opinion being that the interests of the State would be much more advanced by encouraging the ownership of small tracts, which would be more thoroughly cultivated than in large tracts, for what we need is population, and a population of workers. So we conferred with the State authorities to see whether any large grant of land could be secured for this purpose, and we found that the law was so framed as almost to prohibit the State itself from taking advantage of its own grant.

We found that of the grant of 2,500,000 acres of land to this State, 2,000,000 have been selected by private applicants, and that a balance of 500,000 acres only remains; that under existing laws an applicant might apply to the State for 640 acres of this grant, and upon making the deposit required by law the State would then, as his agent, select the land designated by him and make application to the Federal Land Office for the listing of the same to the State. The price fixed is $1.52 an acre.

Section 15 of this act reads as follows: "It is hereby made the duty of the State land registrar to select as portions of the several grants of land to this State all lands for which money has been deposited under the provisions of this act."

So you will observe that the act provided only for the selections where the deposit was made, and such deposit could be made only by individual applicants for title. We found then that the State was powerless either to reserve or select for itself any portion of its grant. This was a very discouraging view of the situation. Senator Stewart was anxious to secure the title of the Tahoe outlet immediately. He was satisfied that it could only be secured by showing to Governor Stanford some reasonable scheme for its utilization which would redound to the advantage of the

people of the entire State, and he found that the law of the State itself held it in chains.

I suggested that a number of individuals could combine together, make applications under the law, make the deposit required and hold the lands for such a projected scheme, not for themselves but for the benefit of the State—the legislation to be shaped at the coming session—and I said that I would advance whatever moneys were necessary to make such deposits. We have now under consideration the selection of from 25,000 to 30,000 acres of land with a view to setting them aside for the benefit of this State or of this county, and of developing a colonization scheme which will increase the wealth, the population, and the prosperity of the State.

When that land is secured and the certificates of purchase are so placed as to secure to the State or to the county of Washoe the benefit of the enterprise, I have no doubt that Governor Stanford will take some measures for the utilization of the storage of Lake Tahoe, either by conveying this land to the State commission of reclamation, or by leasing it perpetually, or by placing it in charge of some one who will act disinterestedly for the owners as well as for this community.

Whilst these negotiations were pending I purchased for $18,000 the outlet of Lake Donner. The facts connected with this purchase have been made public, and it is hardly necessary for me to repeat them. I hold this land subject to reimbursement of the cost and interest at 6 per cent. for the people of the State or of Washoe County, or of the united ditches of the Truckee, as may be deemed advisable. A dam is already raised 6 feet high, and we propose to raise it 6 feet more. This will bring it to the meander line. We propose also to dig down 4 feet, thus giving a height of 16 feet, or 32 square miles of water 1 foot deep.

I was disposed to purchase the lands of riparian owners along the lake if they could be secured reasonably, and raise it 6 feet higher still, but the rapacity of some of these riparian owners has been aroused and they are exceedingly unreasonable in their demands. I do not propose to submit to them, and I trust this community will not. I propose to go on with the enterprise and perfect it so far as I can, and within a short time the question will come up as to what disposition you wish to be made of them. Shall these reservoir sites and these lands be turned over by me to the State commission of reclamation appointed by the State legislature, or shall I hold them until they can be turned over to the county of Washoe under legislation to be secured at the next session? Or shall I turn them over to the united ditches of the Truckee. There is much to be said in favor of each of the propositions. The advantages in favor of turning over these enterprises to the State commission of reclamation are the following: They can be immediately turned over; that commission has $100,000 appropriated for such purposes. The difficulties which have heretofore laid in the way of the commission's entering upon these enterprises have been: First, doubts as to their powers; second, doubt as to the wisdom of obtaining property in California which will be subject to taxation there; third, the supposed onerous nature of the rates to be exacted for the use of water under the law. The commissioners have insisted until recently that it would be their duty to demand a dollar an acre for every acre which received any benefit from this storage. It was thought this would impose a very onerous obligation upon the people of Washoe; assuming that we should succeed in developing only the Donner Lake storage, it would involve the payment from the 25,000 or 30,000 acres of this county now under cultivation of a sum almost equal to the purchase money. In other words, the owners of irrigated lands would be compelled to pay to the State every year the entire amount expended by the State in the enterprise.

This, I understand, is the construction of the law placed upon it by Mr. Evan Williams, chairman, but some gentlemen in this county, among them Mr. Foley, differ with Mr. Williams as to the construction of the statute, and insist that the exaction of $1 an acre applies only to new lands placed under irrigation; but as to old lands covered by existing ditches, the commissioners are under section 8 of the act authorized to fix rates according to their discretion, and that hence they can fix a nominal rate of 10 or 20 cents an acre, which would work no injustice to the owners of land in the Truckee meadows now under cultivation.

All these questions will require time to determine, and possibly an application to the courts will be necessary. My judgment is that in the district of the Truckee, situated as it is all within one county, it is better to intrust the control of these storage reservoirs to the county itself or to the united ditches; otherwise you will find difficulty in having speedy action when energy is required. The members of the State commission are four in number, and live in different parts of the State; they had all-important business interests; it requires three to make a quorum. The fact that we have only been able to secure the presence of one commissioner to-night shows how difficult it will be to secure the attendance of a quorum when some emergency may demand it.

But as to the ownership of the county, it is admitted that under the existing law the county has no power to acquire such properties, and it will be necessary to shape

legislation one year hence to that end. As to the acquisition of these storage reservoirs by the present owners of the ditches on the Truckee, this will meet with the opposition of Governor Stanford and may defeat the acquisition of Lake Tahoe. It will be necessary to overcome his objections by a negotiation and by satisfying him that this measure will advance the general good.

For my own part I incline to the view that the ownership of the storage reservoirs should be vested in the united ditches of the Truckee, through the intervention of some corporation or trustee holding for them. These ditches are about forty in number. The stock in them is for the most part in the ownership of the farmers whose lands are irrigated. No community of interest could be devised which would include a greater number of those to be benefited than would this plan. It would secure the old settlers against loss of their crops, and as the storage was gradually extended these ditches would be enlarged so as to take in new lands within their reach, and when these were all put under cultivation new ditches could be constructed to lead the surplus waters to the high lands above the Truckee meadows. And such ditches should be allowed to appropriate water from the river, both the natural flow and the flow acquired by storage, subject, of course, to prior rights, for it must be remembered that the great cost of these enterprises would not be in the storage of water as much as in the construction of long and expensive ditches running along a precipitous river bank and requiring in places flumes, tunnels, and distributing reservoirs. I am told that the lowest sum for which the cheapest of these ditches—the one projected by Alvaro Evans—can be constructed is $100,000, with a capacity for supplying not more than 4,000 acres of land. Other ditches which have been projected will cost from $250,000 to $300,000 each, thus involving an outlay for water of from $25 to $40 per acre. It will be readily seen that these measures can only be worked out gradually, and as the growth of the community warrants. These views have been most admirably expressed in a letter written by Mr. Robert L. Fulton to Mr. W. H. Mills, the general land agent of the Central Pacific, a man of large and comprehensive views, who will doubtless bring them to the attention of Governor Stanford and Mr. Crocker. I trust that this letter will be published, as it does away with many exaggerated views which I, in common with most others, have indulged as to the area of additional land which can be covered by stored waters, and deals with the whole subject practically and in detail.

It has been suggested that, as I am not purchasing these properties for my personal benefit, I should put the nature of my trust in some legal form; whilst nobody impugns the possibility of my acting in anything but good faith as long as I live, the suggestion is made that I might die, and then there would be a difficulty in enforcing the trust. This is an objection, and I will be glad to take some action which will do away with it. We are about to shape the title to these reservoir sites for all time, and we must carefully consider the plan and the mode, and were I to express my trust in plain and unequivocal terms, acting upon present information, the terms of the trust might prove to be inadequate, and yet could not be changed. It seems to me, therefore, that there is no other course for me to pursue, save as I have done—to acquire the properties and wait until a plan for turning them over can be properly formulated. If I live I know that you will trust me in the matter, and should I die you may rest assured that my executors will not wrong you.

As I have already stated, I have given but little attention to the legal questions involved. I have been too busy with the practical ones. I always give full force to questions that are raised as to legal power, but I have seen great enterprises fail from too great attention to legal obstructions, and in reaching out for a great enterprise my disposition is to fix my eye on the goal and to jump all intermediate fences. I believe that we are on the road to a solution of all the practical difficulties, and when they are solved you may rest assured that the legal difficulties will also disappear.

USE AND CONTROL OF WATERS FROM THE EASTERN SIERRAS, BY ROBERT L. FULTON.

[This letter was written to the land commissioner of the Central Pacific Railroad.]

Heretofore the entire water supply of Lake Tahoe has been used in the interest of concerns located on the upper end of the stream, without any reference whatever to the ten thousand people who have settled on its banks lower down, on lands made fruitful by its waters and their hard labors, and it is to secure, if there is any earthly way to do it, some modification of this arrangement that we importune Governor Stanford and his associate owners in the Donner Boom and Lumber Company.

The people of Washoe County, in which the entire agricultural resources of the Truckee basin lie, know very well that the complete control of its waters can not be transferred to them, for they are aware that the Truckee Lumber Company has a right to water sufficient to furnish power to turn the wheels of their saw-mills and *furniture factory*, but they believe that the interests of the farming communities on

the Truckee could be much better served than at present without in any way decreasing its usefulness to the others who use its waters.

The most rigid economy should be exercised in saving all that falls from the clouds, as well as in its use after it is stored. Last winter and the one before the ice men whose ponds lie on the river complained to the men who have charge of your dam at the outlet that they had too small a flow of water, and insisted that they must have a regular and constant stream flowing through their ponds. The water was allowed to run full head for some time with no further examination or consideration, and what would have been of immense benefit here in maturing crops at a critical period, went to add a few tons in weight or a fraction in quality to the crops of the few ice companies that have their ponds on the main stream. The large ponds of the Prosser Creek, Boca, and Mountain Companies are on side streams and only the newer works are on the river proper.

I have carefully computed the area of its surface, and find the lake to cover 190 square miles and the catchment outside of water to cover 291 square miles. On the south end of the lake the natural course of the streams has not been interfered with, but on the north and east sides it has been diverted. The Virginia and Gold Hill Water Works are supplied by water saved in reservoirs on the west side of the ridge and conducted through a tunnel to the eastern slope and thence in pipes and flumes to their works. The Carson and Tahoe Lumber Company's flume is largely fed from streams that nature originally sent into Tahoe. The change throws the water into the valley south of Carson City. The same is true of the Sierra Nevada Wood and Lumber Company's flume, which carries a large stream into the valley north of Carson.

Making allowance for these diversions on the eastern side for the very narrow limits of the ridge on the north and the break made in the western wall by the Truckee River flowing through it, I do not think it possible to save more than an average of 2½ feet a year.

The highest the lake was ever raised in one year was 3 feet 7 inches, and the average, allowing for the drain that would be made by the interests that would have to be considered, and that need more or less water in the stream all the time, would certainly not exceed 30 inches. If it could be that amount regularly it would be better, but where it is 3 feet one year and 1 foot the next it can not be used economically. There will not be much gained by trying to hold water over for a dry year, the evaporation being so great, and the waste continues day and night. Much of the basin extends toward the east, where the annual deposit of moisture is small, and what does not fall can not be saved. * * *

Major Powell estimates that a foot of water in a reservoir will irrigate an equal amount of land. If he has a square mile of water 1 foot deep he can raise a crop on 640 acres. This might do in a fruit orchard or a grain field, but it will take that much a month on the alfalfa fields of this county. No one figures on using less than three-quarters of an inch, miner's measure, to the acre, and very few on less than an inch. This corresponds very closely, I find, with the estimates made in Spain and elsewhere, according to the reports of General Greeley of the Weather Service, who gives the figure at 5 inches a year. Of course, our farmers raise two and three crops a year, and after the last one they irrigate for pasture until heavy frosts come.

A little calculation will show that the flow of an inch to the acre will be considerably over a foot deep for each month it runs, and that is allowing nothing for seepage or evaporation on the way from the reservoir to the field, which in this case would be from 50 to 80 miles. The Truckee is so steep and full of large bowlders that all the water that comes down gets well aerated, and the evaporation is considerable.

It seems very plain to me, therefore, that if this country was all open, the best that Lake Tahoe could be made to irrigate with the water saved up would not be outside of 50,000 acres. This is beside the natural flow, which was long since appropriated under the laws, and all we can figure on owning is what we can save out of the surplus floods of winter and spring.

There are now about forty ditches, all of them taking their water from the river, and furnishing enough to irrigate, in ordinary years, something like 25,000 acres of land. In such a dry year as this a reserve of water would have added 30 per cent. to the crops on this land, without adding 5 per cent. to the expenses, because all the work of irrigating, harvesting, etc., had to be done as thoroughly for half a crop as for a whole one. To insure a community like this against a failure of even one of its staples is worth a large amount of effort. If the alfalfa crop could have been increased by 10,000 tons this season it would have affected every interest that has a representation in Nevada. Beef cattle would have been shipped in to fatten on it, and trade, industry, transportation, and everything else would have had its share.

It seems to me that the first consideration in any system of water storage should be to prevent a famine in works already constructed. No new settler can have any greater claim on the country, the Government, or the philanthropist than those who came in first and pioneered the country when no one believed it would ever be worth

living in. Of all the ditches on the map not one was built by capital for the sake of the investment. Every one was built by the owners of land to cover the fields they were tilling for their own and their families' support. Many of them worked with a rifle within reach to protect themselves from the treacherous Washoe or Piute, and I claim they are entitled to as much consideration as the pioneers of Kentucky or the forty-niners. All these ditches are owned and operated to this day, directly by the farmers who use the water, except the Steam-boat ditch, which proved too much of an undertaking for the farmers who united to build it. It was sold by the sheriff and is now owned by an estate that offers it for sale for a third of its cost. This and the one used to supply the Reno Water-Works are the only ones not owned by the actual users.

I mention this fact to show you and Senator Stanford that if it was deemed best to sell the control of the outlet to these ditch companies it would be put to the highest possible use, and in case there was a surplus there is a large field beyond their present termini to which they could be carried and the entire waters of Tahoe used to make new homes for citizens. Very fine lands could be reached by extending the Orr ditch and enlarging it to carry water for Spanish Spring Valley. Settlers could take water from the end of the Highland ditch and construct a canal of their own into Prosser Valley and higher up in Spanish Springs than the Orr ditch can reach. Another colony could carry the water of Steam-boat ditch across the valley to fertile lands east of Steamboat Creek. There is a fine tract of land to be covered below the present Steamboat ditch and another below the Orr ditch, but neither can furnish the water until the supply in the river is increased and their carrying capacity multiplied. There is a large opportunity for bringing water and land together to the east of Wadsworth, but it has never been surveyed, so I can not give the data. The water should be used higher up on the stream first for the seepage is so great that with large bodies of land well soaked on the upper waters of a stream there can never be a scarcity below. This has been carefully estimated in Colorado, and the result showed that it was far better for the people on a stream to have farmers come in above them and irrigate than to have all to themselves, as the water was held back and worked its way into the stream again throughout the whole season instead of rushing by in a flood.

IRRIGATION LAWS OF NEVADA.

AN ACT to regulate the use of water for irrigation and for other purposes; for settling the priority of rights thereto, and to punish the unlawful interference with such rights; to provide for the condemnation of land for reservoirs; for recording claims to water rights, and the appointment and duties of water commissioners.

The people of the State of Nevada, represented in Senate and Assembly, do enact as follows:

SECTION 1. That the lands now irrigated, or which may hereafter be irrigated in the State of Nevada, are hereby divided into the following irrigation districts: District No. 1 shall consist of all the lands irrigated from the Truckee River and its tributaries. District No. 2 shall consist of all the lands irrigated from the Carson River and its tributaries. District No. 3 shall consist of all the lands irrigated from the East and West Walker Rivers and their tributaries. District No. 4 shall consist of all the lands irrigated from the Humboldt River and its tributaries. District No. 5 shall consist of all the lands irrigated from the Owyhee River and its tributaries. District No. 6 shall consist of all the lands irrigated from the Rees River and its tributaries. District No. 7 shall consist of all the lands irrigated from the White River and its tributaries. District No. 8 shall consist of all the lands irrigated from the Muddy River and its tributaries. Other irrigation districts may be formed from time to time by the governor, on petition of the parties interested, comprising territory not within any of the above-established irrigation districts.

SEC. 2. There shall be one water commissioner for each of the above-named districts and for each district hereafter formed, who shall be appointed by the governor whenever his service may be required, to be selected by him from the persons recommended to him by the several boards of county commissioners of the counties in which the water districts may extend, and the water commissioners so appointed shall hold office for the period of two years, or until their successor is appointed and qualified. The governor, by like selection and appointment, shall fill all vacancies which may be caused by death, resignation, or continued absence from the district, removal or otherwise, and the governor may at any time remove any water commissioner for failure to perform his duties or for any other cause.

SEC. 3. That within twenty days after his appointment, and before entering upon the duties of his office, such water commissioner shall take and subscribe to an oath to faithfully and impartially perform the duties of his office, which oath shall be deposited with the clerk of the court having jurisdiction over his district.

SEC. 4. It shall be the duty of said water commissioners to divide the water in the natural lakes or streams of their districts among the several ditches taking water from the same according to the prior rights of each respectively, in whole or in part, and to shut and fasten, or cause to be shut and fastened, the head-gates of any ditch or ditches heading in any of the natural streams or lakes of the district, which in time of a scarcity of water makes it necessary by reason of the priority of the rights of others above or below them on the stream.

SEC. 5. Every person who shall wilfully open, close, change, or interfere with any head-gate or water-box without authority shall be guilty of a misdemeanor, and on conviction thereof shall be fined in any sum not exceeding five hundred dollars, or imprisoned in the county jail for a term not exceeding six months, or both such fine and imprisonment. The water commissioners, or their assistants, within their districts, shall have authority to arrest any person or persons offending, and take them before the nearest justice of peace in the county, to be dealt with as in other cases.

SEC. 6. The water commissioner herein provided shall be entitled to pay at the rate of five dollars per day for each day he shall be actually employed in the duties of his office, not to exceed ninety days in any one year, to be paid by the county in which his irrigation district may lie. Each water commissioner shall keep a just and true account of the time spent by him in the duties of his office, and shall present a true copy thereof, verified by oath, to the board of county commissioners of the county in which his district may be, and said board of county commissioners shall allow and pay the same out of the county treasury, and where irrigation districts shall extend into two or more counties then said water commissioner shall be paid for his services as follows: In District No. 2, Douglas County shall pay ——, Ormsby County shall pay ——, Lyon County shall pay ——, Churchill County shall pay ——. In District No. 3, Esmeralda County shall pay ——, Lyon County shall pay ——, Douglas County shall pay ——. In District No. 4, Humboldt County shall pay three-sevenths ——, Lander County shall pay one-quarter ——, Eureka County shall pay one-quarter ——, Echo County shall pay three-sevenths ——. District No. 6, Lander County shall pay ——, Nye County shall pay ——. Said water commissioner shall have power, in case of emergency, to employ suitable assistants to aid him in the discharge of his duties; such assistants shall take the same oath as the water commissioner and shall obey his instructions, and each shall be entitled to four dollars per day for every day he is actually employed, not to exceed thirty-five days in any one year, to be paid upon the certificate of the water commissioner in the same manner as is provided for payment of water commissioners.

SEC. 7. Said water commissioners shall not begin their work until they shall be called by three or more owners or managers or persons controlling ditches in their several districts by application in writing, stating that there is a necessity for their action, and they shall not continue performing services after the necessity therefor shall cease.

SEC. 8. For the purpose of hearing, adjudicating, and settling all questions concerning the priority of the appropriation of water between ditch companies and other owners of ditches drawing water for beneficial purposes from the same stream or its tributaries or lakes, within the same irrigation district, and all other questions of law and questions of right growing out of or in any way involved or connected therewith, jurisdiction is hereby vested exclusively in the several district courts as follows: For district No. 1, in the district court of the State of Nevada, Washoe County; for district No. 2, in the district court of the State of Nevada, Ormsby County; for district No. 3, in the district court of the State of Nevada; for district No 4, in the district court of the State of Nevada, for either Humboldt or Elko Counties; for district No. 5, in the district court of the State of Nevada; for district No. 6, in the district court of the State of Nevada, Lander County; for district No. 7, in the district court of the State of Nevada; for district No. 8, in the district court of the State of Nevada. All lakes, streams, and reservoirs not herein enumerated shall be for all purposes attached to and belong to the irrigation district in which the greater portion of its waters is, it being the intent and meaning hereof to add to each irrigation district all waters not hereinbefore enumerated, the majority of which lie within their respective areas, for the purpose of acquiring rights to the appropriation and use thereof and adjudicating the same.

SEC. 9. In order that all parties may be protected in their lawful rights to the use of water for beneficial purposes, every person, association, or corporation owning or claiming any interest in any ditch, canal, or reservoir within any water district, shall, on or before the first day of September, eighteen hundred and eighty-nine, file with the county recorder of the county a statement of their claim under oath, entitled of the proper county, which statement shall contain the name or names, together with the post-office address, of the claimant or claimants claiming ownership as aforesaid of any such ditch, canal, or reservoir, the name thereof (if any), and if without a name the owner or owners shall choose and adopt a name to be therein stated by which such ditch, canal, or reservoir shall thereafter be known; the de-

scription of such ditch, canal, or reservoir as to location of head-gate, general course of ditch, the name of the natural stream or lake from which such ditch, canal, or reservoir draws its supply of water; the length, breadth, depth, and grade thereof as near as may be; the time, fixing a day, month, and year as the date of appropriation of water by original construction, also by the enlargement or extension, if any such thereof have been made, and the amount of water claimed by or under such construction, enlargement, or extension, and the present capacity of the ditch, canal, or feeder of reservoir, and also the number of acres of land lying under and being, or proposed to be, irrigated by water from such ditch, canal, or reservoir; or if such waters have been appropriated for other beneficial purposes than irrigation, a statement of such purposes. Said statement shall be signed by the proper party or parties and filed with the recorder of the county wherein the right claimed is situated, which shall be recorded by him in a book kept for that purpose.

SEC. 10. Upon the filing of such statement the recorder shall indorse upon the back thereof the date of filing, and shall prepare an index of the same in a book to be provided for that purpose by the county commissioners, which said index shall contain the date of filing, the name of the party, association, or corporation, the name of the ditch, the stream from which the water is taken by such ditch, canal, or reservoir, the location of the head-gate, the date of the appropriation of the water by construction, enlargement, or extension. Said index shall be prepared alphabetically by reference to the name of the ditch, canal, or reservoir.

SEC. 11. For filing and indexing such statement the recorder shall receive the same fees as for recording deeds, to be paid by the party or parties filing the same.

SEC. 12. That hereafter every person, company, or corporation constructing, enlarging, or extending any ditch, canal, or reservoir for beneficial purposes, and intending to use or appropriate any water from any natural stream or lake within any water district for such beneficial purposes, shall file with the county recorder of the proper county before the commencement of the construction, enlargement, or extension of such ditch, canal, or reservoir, a statement showing the stream or streams from which the water is to be taken; the point or place on said stream at or near which the water is to be taken out; the line or commencement of said ditch or ditches as near as may be; the use or uses to which said water is to be applied; the dimensions of said ditch or ditches, and each thereof, giving width on bottom and top, slope of banks, and grade of ditch, and likewise of any and all enlargements thereof, which statement shall be filed and indexed as is provided in section 9 of this act; and from the time of filing any such statement water sufficient to fill such ditch or ditches and subserve the use or uses aforesaid, if a lawful and just use, shall be deemed and adjudged appropriated: *Provided*, That nothing herein contained shall be permitted to interfere with a prior right to said water or to any thereof: *And provided further*, That such person or persons or corporation shall, within sixty days next ensuing the filing of such statement, begin the actual construction of said ditch or ditches, and shall prosecute the work of the construction thereof diligently and continuously to its completion: *And provided further*, That the beginning of all necessary survey of such ditch or ditches shall be construed as the beginning of said work of construction.

SEC. 13. The water of every natural stream not heretofore appropriated within this State is hereby declared to be the property of the public, and the same is dedicated to the use of the people, subject to appropriation as herein provided. The provisions of this act shall apply to all cases where the water of natural streams or lakes is appropriated for beneficial purposes, whether the water be conducted through ditches, canals, flumes, or tunnels, and shall apply also to cases where for irrigation purposes the water is stored in reservoirs, and the owner or owners of any ditch, canal, flume, or tunnel through which water is conducted for irrigation purposes, and also the owners of reservoirs, may conduct the water therefrom into and along any of the natural streams of the State, but not so as to raise the waters thereof above high-water mark, and may take the same out again at any point desired; but due allowance shall be made for evaporation and seepage, the amount to be determined by the water commissioner of the proper district, subject to review and determination by the court having jurisdiction over priorities in such districts.

SEC. 14. Whenever any person or persons, association or corporation, interested as owners of any ditch, canal, or reservoir in any district, shall desire a determination of the priorities of rights to the use of water from any stream or streams from which they draw the water for their ditch or ditches, canals or reservoirs, they shall present to the district court having jurisdiction over the rights in such water district, or to the judge thereof, a petition or application in writing, moving or praying said court to proceed to an adjudication of the priorities of rights to use of the water for irrigation, between the several ditches, canals, or reservoirs, in such district, on the stream or streams named in such motion, petition, or application. The said motion, petition, or application shall state the names of the ditches, canals, or reservoirs claiming

water from said stream or streams as appears from the final statements in the recorder's office, together with the names of the persons, associations, or corporations interested therein, taken from said statements, and shall set forth the nature of the claim or claims of the applicant or applicants, and such motion, petition, or application shall be entitled "In the matter of an application for an adjudication of the priorities of rights to use water for beneficial purposes in water districts. District No. ——, on ——" (stating the stream or streams). Upon the filing and docketing of such application, the court or judge thereof shall, without unnecessary delay, by an order to be entered of record upon such petition or application, appoint a day for commencing to hear and take evidence in such adjudication, at which time it shall be the duty of the court or judge thereof to proceed and hear all evidence that may be offered by or in behalf of any person, association, or corporation interested in stream or streams in such district, in any ditch, canal or reservoir, either as owner or consumer of water therefrom, in support of or against any claims of priority of appropriation of water made by means of any ditch, canal, or reservoir, or by any enlargement or extension thereof in such district, or on such stream or streams, and consider all such evidence, also the arguments of the parties or their counsel, and shall ascertain and find from such evidence, as near as may be, the date of the commencement of such ditch, canal, or reservoir, together with the original size and carrying capacity thereof as orginally constructed; the time of the commencement of each enlargement or extension thereof, if any, with the increased capacity thereby occasioned; the time spent severally in such construction, enlargement, or extension, and re-enlargement, if any; the diligence with which the work was in each case prosecuted; the nature of the work as to the difficulty of construction, and all such other facts as may tend to show the compliance with the law in acquiring the priority of right claimed for each such ditch, canal, or reservoir, and determine the matters put in evidence, and make and cause to be entered a decree determining and establishing the several priorities of right, by appropriation of water of the several ditches, canals, and reservoirs in such water district in such stream or streams, concerning which testimony shall have been offered, each according to the time of its said construction and enlargements and extensions, with the amount of water which shall be held to have been appropriated by such construction and enlargement or extensions, describing such amount by cubic feet per second of time (which shall also be the measurement for the sale of water), if the evidence shall show sufficient data to ascertain such cubic feet, and if not, by width, depth, and grade, and such other description as will most certainly and conveniently show the amount of water intended as the capacity of such ditch, canal, or reservoir. In such decree such court or judge thereof shall receive from the clerk, on payment therefor, a certificate, under seal of the court, showing date or dates and amount or amounts of appropriations adjudged in favor of such ditch, canal, or reservoir, under and by virtue of the construction, extension, and enlargement thereof severally, also specifying the number of said ditch, as determined by said court, with reference to priority and of each priority to which the same may be entitled by reason of said construction, extension, and enlargements; provided, that any party or parties claiming any right to the use of water for beneficial purposes in such district and on such stream or streams by reason of being owner of or interested in any ditch, canal, or reservoir, who is not mentioned in the petition or application, and shall become parties to such proceedings and shall have their rights adjudicated therein. The court, or judge thereof, may, instead of taking the testimony orally or in open court, refer the matter to a referee, with such powers as in other cases. The testimony may be taken at any place ordered by the court, or judge thereof, or by the referee.

SEC. 15. The holder of the certificate provided for in section fourteen, shall exhibit the same to the water commissioner of the district when he commences the exercise of his duties, and such water commissioner shall keep a book in which he shall enter a brief statement of the contents of such certificate and which shall be delivered to his successor, and said certificate, or statement thereof in his book, shall be the warrant of authority to said commissioner for regulating the flow of water in relation to such ditch, canal, or reservoir; said certificate shall be recorded at the same rates of charges as in case of deeds of conveyance in the records of each county into which the ditch, canal, or reservoir, to which such certificate relates, shall extend; and said certificate, or said record thereof, or a duly certified copy of such record, shall be prima facie evidence of so much of the decree as shall be recited therein in any suit or proceeding in which the same may be relevant.

SEC. 16. Upon the order of the court fixing the time of such hearing being made, the clerk shall make a certified copy of such order, which order shall contain the names of all parties alleged in the application to be interested in the matter, which shall be thereupon served upon each of the parties therein named, in the same manner as summons. It shall be the duty of the clerk also to give public notice of such application in a newspaper, if any printed and in circulation, in each county wherein

such water district is situated, which shall be published at least twenty days, and which said notice shall contain the date of the filing of said petition or application, the name or names of the parties filing the same, a copy of the order made by the court of hearing, and shall notify all parties interested as owners in any ditch, canal, or reservoir, on such stream or streams, in such water district, as well as the persons named in the petition or application, to appear at said court, or before the judge thereof, at the time appointed and stated in the order; and all persons interested as owners or consumers may then and there present his or her or their proofs for or against any priority of right of water by appropriation sought to be shown by any party, by or through any ditch, canal, or reservoir (either as owner or consumer of water therefrom), and in case any party mentioned in the petition or application can not be personally served in any county embraced in such water district, the published notices above provided shall be deemed sufficient service of notice: *Provided further*, That in addition to such publication the clerk shall mail such published notice to each party mentioned in the petition or application, directing the same to the address of the parties, as stated in the sworn statement on file. Proof of the proper publication shall consist in the sworn certificate of the publisher of the paper in which notice is published, to which shall be attached a printed copy taken from such paper.

SEC. 17. Any person or persons who shall willfully cut, dig, or break down or open any gate, bank, or embankment or side of any ditch, canal, or reservoir, flume, pipe, tunnel, or feeder in which such person or persons may be joint owners or which is the property of another or in the lawful possession of another or others and used for the purpose of irrigation, milling, manufacturing, mining, or domestic purposes, with intent maliciously to injure any person, association, or corporation, or for his or her own gain or with the intention of stealing, taking, or causing to run or pour out of such canal or reservoir, feeder, pipe, or flume any water for his or her own profit, benefit, or advantage, or to the injury of any other person, persons, association, or corporation lawfully in the use of such water or of such ditch, canal, tunnel, feeder, pipe, or flume, he, she, it, or they so offending shall be deemed guilty of a misdemeanor and on conviction thereof shall be fined in any sum not exceeding $500, and may be imprisoned in the county jail not exceeding six months, or both, at the discretion of the court.

SEC. 18. Any party or parties representing any ditch, canal, or reservoir, or any number of parties representing two or more ditches, canals, or reservoirs which are affected, in common with each other, by any portion of the decree rendered by the district court, by which he, she, it, or they may feel aggrieved, may have an appeal from said district court to the supreme court, and in such case the party or parties joining desiring an appeal shall be the appellants, and the parties representing any one or more ditches, canals, or reservoirs affected in common adversely to the interest of appellants shall be appellees. The party or parties in such appeal shall, within sixty days after the date of the decree is entered under this act, file a notice of appeal in writing stating that such party or parties appeal to the supreme court of the State from the decree rendered in the case or any part thereof. When only a part of the decree is appealed from, the notice of the appeal shall so state and shall also in that case specify the portion or part of the decree appealed from. Upon filing of such notice of appeal the cause shall be deemed to be appealed to the supreme court of the State: *Provided, however*, That the party or parties appealing as aforesaid shall, within sixty days as aforesaid, enter into an understanding to be approved by the district court, or judge thereof, and to be given to all parties in said suit or proceedings other than the parties appealing, and to be in such an amount as the court or said judge shall order, conditioned that the parties giving the said undertaking shall prosecute their appeal to effect and without unnecessary delay, and will pay all costs and damages which the parties to whom the undertaking is given, or either or any of them, may sustain in consequence of such appeal.

SEC. 19. The notice last aforesaid shall be entered of record, and the appellant or appellants shall cause a certified copy thereof to be served on each of the parties or their attorneys, if they have one, as in other cases.

SEC. 20. The appellant or appellants shall, within six months after the appeal be allowed as aforesaid, file in the office of the clerk of the supreme court of the State a certified transcript of the proceedings had in the case in the district court, containing the pleadings and the statements of the parties filed therein and all evidence of record offered on the hearing of the cause, or so much thereof as shall affect the appropriation of water claimed by the means of construction, enlargement, or re-enlargement of the several ditches, canals, and reservoirs mentioned in the order allowing the appeal; such statement to be served, filed, and settled in the same manner as statements on motion for new trials.

SEC. 21. The supreme court in all cases heard before it under this act shall, when it can properly be done, render such decree as the court or judge below should have

rendered. It may either reverse or modify the decree of the court below. If reversed in whole or in part it may direct the court below as to its further proceedings therein.

SEC. 22. No claim of priority of any person, association, or corporation, on account of any ditch, canal, or reservoir, as to which he, she, it, or they have filed or refuse to offer evidence under any adjudication herein provided for, shall be regarded by any water commissioner in distributing water in times of scarcity thereof, until such time as such party shall have, by application to the court having jurisdiction, obtained leave therefor and made proof of the priority of right to which such ditch, canal, or reservoir shall be justly entitled, which shall only be granted upon terms as to notice to other parties interested, and upon payment of all costs, and upon affidavit or petition, sworn to, showing the rights claimed, and the ditches, canals, and reservoirs, with the names of the owners thereof, against which such priority is claimed, nor until a decree adjudging such ditch, canal, or reservoir has been entered, and certificate, such as mentioned in section fifteen thereof, shall have been issued to claimant and presented to the water commissioner.

SEC. 23. No person, association, or corporation representing any ditch, canal, or reservoir shall be permitted to give or offer any evidence before said court until he, she, it, or they shall have filed a statement of a claim, in substance the same in all respects as is required to be filed under the provisions thereof.

SEC. 24. The district court or judge thereof shall have power to order, for good cause shown, upon terms just to all parties, and in such manner as may seem meet, a re-argument or review, with or without additional evidence, of any decree made under the provisions of this act, whenever said court or judge shall find from the cause shown for that purpose by any party or parties feeling aggrieved, that the ends of justice will thereby be promoted, but no such review or re-argument shall be ordered unless applied for by petition or otherwise within one year of the time of entering the decree complained of.

SEC. 25. Persons desiring to construct and maintain reservoirs for the purpose of storing water shall have the right to take from any of the natural streams of the State and store away any unappropriated water not needed for immediate use, for domestic, irrigation, or other needful purposes; to construct and maintain ditches, canals, flumes, and tunnels in the same manner provided by law for the condemnation of lands for right of way for ditches, provided no reservoir with embankment or a dam exceeding 10 feet in height shall be made without submitting the plans thereof to the county commissioners of the county in which it is situated and obtain their approval of said plans.

SEC. 26. The owners of reservoirs shall be liable for all damages arising from leakage or overflow of the waters therefrom, or by floods caused by the breaking of the embankment of such reservoir.

SEC. 27. Every witness who shall attend before the court or judge thereof, or before the person appointed to take testimony, in the causes provided for in this act, under subpœna by request of any party, shall be entitled to the same fees and mileage as witnesses in civil cases in the district court, and shall be paid by the party requiring his testimony. All other costs of the proceeding shall be paid by the parties claiming water, as may be adjudged by the court or judge.

SEC. 28. Whenever, in actions for proceedings, for the determination of water rights, it may become necessary to divide the water of any stream or ditch between the different claimants, it shall be divided, as far as possible, by periods of time, instead of fractional parts of the water.

SEC. 29. Said water commissioners shall so divide, regulate, and control the use of the water of all streams within their respective districts in such manner, as near as may be, as will prevent unnecessary waste of water; and to that end such commissioners shall so shut and fasten the head-gate or gates of all ditches so that no more water will flow into said ditch than is actually required and will be used for the purpose or purposes for which such water was appropriated; and any person may resort to any court of competent jurisdiction for such relief as he may be entitled to.

SEC. 30. Whenever testimony shall or may be taken in any district created by this act for the purpose of procuring decree as to appropriation of water and priorities thereof, any testimony theretofore taken upon the hearing of any former application or petition under this act may be introduced and shall be received as evidence.

SEC. 31. This act shall in nowise be construed as impairing or abridging any rights already vested in any person or persons, company or corporation, by virtue of the law heretofore in force.

SEC. 32. All acts and parts of acts inconsistent with this act are hereby repealed.

SEC. 33. This act shall take effect and be in force from and after its passage.

No. X. Assembly joint memorial and resolution relative to encouraging the sinking of artesian wells, and the assistance, by other means of irrigation, for the arid lands situated within the State of Nevada.

To the honorable the Senate and House of Representatives of the United States in Congress assembled:

Your memorialists, the legislature of the State of Nevada, respectfully represent, that—

Whereas the said State of Nevada did, upon its admission to the Union, receive and acquire five hundred thousand (500,000) acres of land for purposes of internal improvements, under the act of Congress approved September fourth, one thousand eight hundred and forty-one; and

Whereas the said State of Nevada did, upon the adoption of its constitution, pledge and dedicate and transfer the land covered by said grant, and all proceeds therefrom, to the school fund of said State and for school purposes inviolably and forever; and

Whereas by act of Congress approved July fourth, one thousand eight hundred and sixty-six, the said appropriation by the constitution of the State of Nevada to educational purposes of the said lands so granted for internal improvements was approved and confirmed; and

Whereas at the time of said transfer, appropriation, and dedication, as aforesaid, the agricultural interests of the State of Nevada, together with the possibilities of production of its soil, were entirely misunderstood or not understood at all, owing to the prominence then claimed for and given to its great mining industry; and

Whereas the events of later years have conclusively shown that a large percentage of the neglected public lands within the said State are susceptible of a high state of cultivation where irrigation can be had, and will return large and profitable crops of great variety; and

Whereas there now remains of the public lands within said State, including those heretofore granted and pledged for educational purposes, about five hundred thousand acres, which are partially unsalable from the fact that the labor and expense necessary to join water with said land is above and beyond individual effort; and

Whereas the said State of Nevada has now, by existing law, done its utmost to encourage and further the good purposes of this memorial and resolution; and

Whereas such aid as your memorialists pray for will add largely to the income of said school fund of said State, to the proceeds derived by the national Government from sale of lands within its borders, and will add taxable property for all purposes, as well as materially increase the population of said State; and

Whereas by recent enactment and appropriation for hydrographic surveys the Congress of the United States has recognized the necessity of reclaiming lands of the character described within the arid regions, of which this State forms a part, and the fact being that any expenditure within this State for internal improvements could only be made profitably for the purposes herein written; and

Whereas, in so far as it may be proper for us so to do, we pledge the State of Nevada to aid and encourage the reclamation or sale of said lands to the limits of its capacity: Therefore,

Resolved by the assembly, the senate concurring, That we earnestly petition the Congress of the United States to make such appropriations as it may deem proper to the State of Nevada, and to all other States and Territories where the conditions of soil, climate, and rain fall are similar to those found within said State; or that the Congress of the United States do make to this State, as well as to other States and Territories in like condition and situation, a grant of a sufficient portion of the public lands as yet unappropriated and within said State or Territory, which said grant and land, and all proceeds therefrom, shall be by said State or Territory held and used solely and entirely for the uses and purposes hereinabove written, viz: To encourage the sinking of artesian wells upon public lands, in assisting settlers in good faith to conduct waters now running to waste to and upon portions of said land.

Resolved, That we earnestly urge upon Congress immediate consideration of this memorial.

Resolved, That the governor be requested to forward a certified copy hereof to our Representative in Congress and each United States Senator from the State of Nevada, with the request that they use all honorable means to secure an early and favorable consideration therefor.

Passed February 6, 1889.

AN ACT defining and prohibiting the unlawful diversion and waste of water.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. Any person or persons who shall, during the irrigating season, divert and conduct the water, or portion thereof, of any river, creek or stream into any slough or sloughs, dam or dams, pond or ponds, and retain, or cause the same to be held or retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any such river, creek or stream, and run, or cause or allow the same to run to waste on sage-brush or greasewood land, such diversion shall be deemed an unlawful use and waste of water.

SEC. 2. Any person or persons, company, corporation or association who shall, during the irrigating season, divert and conduct, or any person or persons aiding, abetting or assisting any such person or persons, company, corporation or association in diverting and conducting, during the irrigating season, the water, or portion thereof, of any river, creek or stream into any slough or sloughs, dam or dams, or pond or ponds, and retain, or cause the same to be retained therein without making any other use of such water, or who shall, during the irrigating season, divert and conduct the water, or portion thereof, away from any river, creek or stream, and run, or cause or allow the same to run to waste, contrary to and in violation of the provisions of this act, shall be guilty of a misdemeanor, and upon conviction thereof, in any court of competent jurisdiction in this State, shall be punished by a fine not exceeding five cundred dollars or by imprisonment in the county jail of the county not exceeding hix months, or by both such fine and imprisonment.

Approved February 28, 1889.

CHAP. CXII.—AN ACT to provide for the storage of water, to encourage milling, mining, and internal improvements, and to reclaim the arable desert lands and develop the agricultural resources of the State of Nevada, and to provide funds for the payment of the same.

Whereas the State of Nevada has received from the General Government a grant of two million acres of land in lieu of the sixteenth and thirty-sixth sections, previously granted to the State of Nevada, the proceeds from the sale of which are to be placed to the credit of the school fund of the State; and

Whereas under an act of Congress approved September 4, 1841, and an act approved March 21, 1864, a grant of 500,000 acres of land was made to the State of Nevada for internal improvements; and

Whereas the selection of said lands are not confined to any particular section of unappropriated land; and

Whereas the greater portion of unappropriated lands in the State of Nevada is known to be desert, waste, and actually valueless and without sale, unless water, for the purpose of irrigation, can be brought upon them, and the land properly and systematically irrigated, crops of all kinds can not be successfully raised; and

Whereas the permanent settlement, growth, wealth, and independence of the State and people, as well as the sale of school lands, depend upon the reclamation of these desert lands: Now, therefore,

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. A board of reclamation commissioners is hereby created, to consist of four members, to be known as the "board of reclamation and internal improvements," for the storage of water and reclamation of arable desert lands in this State. Said board to consist of J. F. Ciark, of Humboldt County, Evan Williams, of Ormsby County; J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County. The said J. F. Clark, of Humboldt County, and Evan Williams, of Ormsby County, to hold the position for the term of four years, or until the election of their successors, and the said J. R. Bradley, of Elko County, and Herman Springmeyer, of Douglas County, to hold the position for the term of two years, or until the election of their successors. The State of Nevada is hereby divided into seven internal improvement and reclamation districts, of which Douglas, Ormsby, Esmeralda, Lyon, and Storey, shall constitute the first district, Washoe County, the second district, Churchill County, the third district, Humboldt County, the fourth district, Elko County, the fifth district, Lander, Eureka, and White Pine Counties the sixth district, and Nye and Lincoln Counties the seventh district. At the general election in eighteen hundred and ninety, and at each general election thereafter, there shall be elected from the State at large two reclamation commissioners, one who shall serve for the term of two years, and one for the term of four years, from and after the first Monday in January next succeeding such election.

The office of said board shall be in the State capitol building, at the seat of government. The board shall adopt rules and regulations for the transaction of its business.

SEC. 2. The board of reclamation shall invite, receive, and procure information and statistics in regard to all public lands within this State, and the waters running therein, which are or may become possible of reclamation, by means of conducting upon them the unappropriated waters running through natural or artificial channels within this State, and shall report the same, together with an approximate estimate of costs and result of such proposed reclamation, at each biennial session of the legislature.

SEC. 3. The board of reclamation shall also invite, receive, procure, and publish facts and statistics regarding the natural water-courses of this State and several districts, including source, supply, water power, and other matters relating to the value of said waters, or the most practical methods of utilizing the same, either for milling, mining, manufacturing, or agricultural purposes, in order that said information may be offered for the attraction of dormant capital and the encouragement of individual enterprise.

SEC. 4. It shall be the duty of the surveyor-general, *ex officio*, to furnish the board of reclamation, within a reasonable time, maps, profiles, and estimates to determine the cheapest and most economical and valuable routes for canals, reservoirs, and other improvements for irrigation and milling purposes; and also to furnish maps, plans, and estimates for the purpose of building reservoirs, dams, etc., connected with the storing and preserving of waste water.

SEC. 5. The board of reclamation shall have the power to divide the State into districts, and to appoint a superintendent for each reclamation district within the State, which they may establish and define, whose duty it shall be to superintend the building, constructing, and maintenance of the canals, dams, and other like works within his district as so defined.

SEC. 6. The work of building and constructing any and all canals, dams, and other improvements shall be done by contract, if done by private parties the contracts to be let to the lowest responsible bidder. The work done by contract shall be let in lots of one or more sections, said sections not being more than one mile in length, as indicated by the maps, profiles, plans, and specifications prepared by the surveyor-general and adopted by said board.

SEC. 7. The board of reclamation commissioners of the State are hereby authorized and directed to employ a competent civil engineer to ascertain and report the number of irrigating ditches in each reclamation district, the capacity of the same in inches, and amount heretofore appropriated and used through said ditches.

SEC. 8. Any irrigating ditch now constructed and hereafter carrying more water than reported by said civil engineer, the owner or owners thereof of said ditch shall pay to the reclamatfon fund of the State, for such additional water, such sums or rates as the board of reclamation commissioners shall designate; which sum so paid shall constitute a part of the reclamation fund, and shall be available for demands against said fund.

SEC. 9. Whenever the board of reclamation commissioners deem the reorganization or division of any district advisable for internal improvements contemplated by this act, they shall have power to make such changes and establish such additional rules for the government thereof as will not conflict with prior rights as now recognized by law.

SEC. 10. The board shall have power to purchase or rent such lands for reservoirs, sites, or ditches as they may deem best, whether within or without the boundaries of this State.

SEC. 11. The board of reclamation commissioners, on petition of ten or more persons interested in irrigation ditches in any district in this State petitioning for the issuance of bonds of said district for reclamation purposes, said board shall, at the next general election, submit the question, together with amount of bonds to be issued, to the voters of said district; and, if carried at said election, the said board shall issue and dispose of said bonds under such rules and regulations as they may adopt, the proceeds thereof to be placed in the reclamation fund of the district, and made available for reclamation purposes.

SEC. 12. The board shall advertise for and receive bids upon the work to be done as soon as the surveyor-general can have surveys, maps, plans, specifications, and estimates of the same in readiness for adoption by the board and inspection by bidders, and shall fix a time when they will open bids and award contracts, which shall not be done on less than four weeks' notice thereof, which said notice shall be given for said time by publication in one newspaper in the reclamation district where the work is to be done, or by posting notices.

SEC. 13. The terms of contracting may be to pay monthly, as the work progresses, on the estimate of the surveyor-general or engineer of the amount of work done, seventy per centum of its contract value, reserving to the district or State thirty per *centum of* the value thereof to insure its faithful completion according to contract, *when full* payment shall be made, including the retained per centum.

SEC. 14. The board shall fix a definite day for the final completion of any canal, dam, or other improvement, and require all contracts to be done and completed on or before that day, and shall in any agreement reserve the right of forfeiture to the State or district of any retained per centum, and to award the contract of any person or persons who, in the opinion of the surveyor-general, confirmed by the board, fails to make such monthly progress as will insure the completion of any such work so undertaken or contracted for on the day named.

SEC. 15. The board of reclamation shall, upon organization as herein provided, be authorized, empowered, and directed to construct a canal, ditch, or other proper work at, from, or upon the most desirable and practical point on any river or water-way in the State, or that can be procured—the said point to be hereafter selected by said board—to connect with, and to be connected with, for the purpose of milling or irrigrating the arable lands situate, lying, and being in the accessible vicinity of such selected river or water-way; and the said canal, ditch, or other work shall be built or established upon a grade or plan in accordance with the configuration and necessities of the shortest and most feasible route and safe carriage of the requisite volume of water required to irrigate the lands within the scope of said ditch or work.

SEC. 16. The total cost of said canal, ditch, or work shall not exceed one hundred thousand dollars, and the cost thereof is hereby limited to that sum.

SEC. 17. The board of reclamation shall audit and certify to the State board of examiners the several amounts that may become due from time to time for work and labor done, services or material furnished in and about the location and building of canals and other works of reclamation that may be carried on, built, and completed under the board, and when approved by the State board of examiners, the controller shall audit the same and draw his warrant upon the State treasurer for the several amounts of such claims, to be paid out of the reclamation fund of the State or district.

SEC. 18. The elective members of the board shall be paid their necessary traveling expenses, and they shall receive no other compensation for their personal services.

SEC. 19. It shall be unlawful for any State officer, or any member of the board of reclamation, to be interested, directly or indirectly, or to take or have any interest or profit, in any manner, in any work of constructing any canal or other improvement for reclamation under this act, and upon conviction shall be fined in any sum not less than one thousand dollars nor more than ten thousand dollars, or imprisonment in the State prison not less than one year nor more than five years, or both such fine and imprisonment.

SEC. 20. The annual rent for water within the scope of any canal, ditch, or work created and built by the board of reclamation shall be one dollar per acre per year. Said rental of water shall be held as a lien against said lands.

SEC. 21. The annual rent of water shall be collected in the same manner and by the same officers as taxes are now collected, and paid into the State or district treasury without fee or abatement and accounted for as the water rent, and placed to the credit of the reclamation and internal improvement fund; and it is hereby enacted that all lands sold by the State under the provisions of this act shall be supplied with the necessary water for reclamation whenever in the judgment of the board it is practicable to do so, and the right of way for the secondary ditches is hereby reserved by the State, and shall be reserved and excepted by the surveyor-general and State land register, from every patent issued by the State, to take up, convey, and deliver all waste water over and across any lands sold and conveyed by the State to any person or persons.

SEC. 22. One hundred thousand dollars is hereby appropriated for the construction and building of any canal, ditch, dam, or other work or works mentioned in this act, and in no case shall a contract or contracts be entered into that shall in the aggregate exceed the sum of one hundred thousand dollars for the construction and building of said canal or work.

SEC. 23. The money herein appropriated shall be taken from the State school fund and placed to the credit of the reclamation fund, herein credited, and in its place shall be deposited one hundred bonds of one thousand dollars each, bearing interest at the rate of four per cent. per annum. Said bonds shall run for twenty years, but shall be redeemable by the State at its pleasure after two years. Said bonds shall be signed by the governor and State controller, and countersigned by the State treasurer, and authenticated with the great seal of the State, and shall state in substance that the State of Nevada owes to its school fund one thousand dollars, the interest on which sum, at four per cent. per annum, it agrees to pay until said bond is redeemed for the benefit of the common schools of the State. Said bonds shall be lithographed, as is usual in such cases, and deposited with the treasurer of the State. The interest on said bonds shall be paid semi-annually, on the first day of January and July, on the written order of the State board of education to the State controller, directing him to draw his warrant for the amount of such semi-annual interest on the reclamation interest and sinking fund herein created.

All sums derived from the interest on said bonds shall go into the general school fund for the support of the common schools of the State, and for the regular and prompt payment of which the faith and credit of the State is hereby pledged.

SEC. 24. There shall be levied and collected for the fiscal year commencing January first, A. D. eighteen hundred and ninety-one, and annually thereafter, an ad valorem tax of two cents on each one hundred dollars of all the taxable property in the State, and all sums derived from this tax shall go into the reclamation interest and sinking fund for the payment of the interest and redemption of bonds herein authorized by this act.

SEC. 25. The reclamation fund is hereby made a permanent fund, into which all revenue arising from the last-mentioned section, and from the water rent aforesaid, in section fifteen, and from any other source provided by law, shall be paid and shall be devoted as follows: First, to the payment of interest on bonds; second, to the redemption of the principal sum of the bonds at or before maturity; third, to the reclamation of new districts that may be hereafter created; fourth, to be transferred to the general fund of the State.

Approved March 3, 1889.

CHAP. LXXXVII.—AN ACT to amend an act entitled "An act to encourage the sinking of artesian wells," approved March 5, 1887.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. Section one of said act is hereby amended so as to read as follows:

Section one. Every person, firm, company, corporation, or association, that shall, after the passage of this act, commence the sinking of artesian wells, for stock or agricultural purposes, shall be entitled for sinking such artesian well, where flowing water is obtained, the following specified sums: For the first two hundred feet, one dollar and twenty-five cents per foot; for the third one hundred feet, one dollar and fifty cents per foot; for the fourth one hundred feet, two dollars per foot; for the fifth one hundred feet, two dollars and twenty-five cents per foot; for the sixth one hundred feet, two dollars and fifty cents per foot; for the seventh one hundred feet, three dollars per foot; for the eighth one hundred feet, three dollars and fifty cents per foot; for the ninth one hundred feet, four dollars per foot; for the tenth one hundred feet, four dollars and fifty cents per foot; for all depths exceeding one thousand feet, five dollars per foot for each and every foot below the said one thousand feet. And an additional bounty of one thousand dollars for every well sunk to the depth of one thousand feet or more: *Provided*, That such well shall furnish twenty thousand gallons of water each twenty-four hours, flowing continuously for thirty days, said sums to be paid in the manner provided for in sections four and five of this act: *Provided*, That no bounty shall be paid on any well which does not furnish seven thousand gallons of water in each twenty-four hours, flowing continuously for thirty days: *And provided further*, That no two wells shall receive a bounty if located within the same county. Where two or more wells within the prescribed limit apply for a bounty, the well which first furnished the amount of water required by this act shall be entitled to the bounty allowed by this act.

SEC. 2. Section six of said act is hereby amended so as to read as follows:

Section six. The sum of ten thousand dollars is hereby appropriated out of any money in the general fund of this State for the payment of bounties herein provided for.

Approved March 7, 1889.

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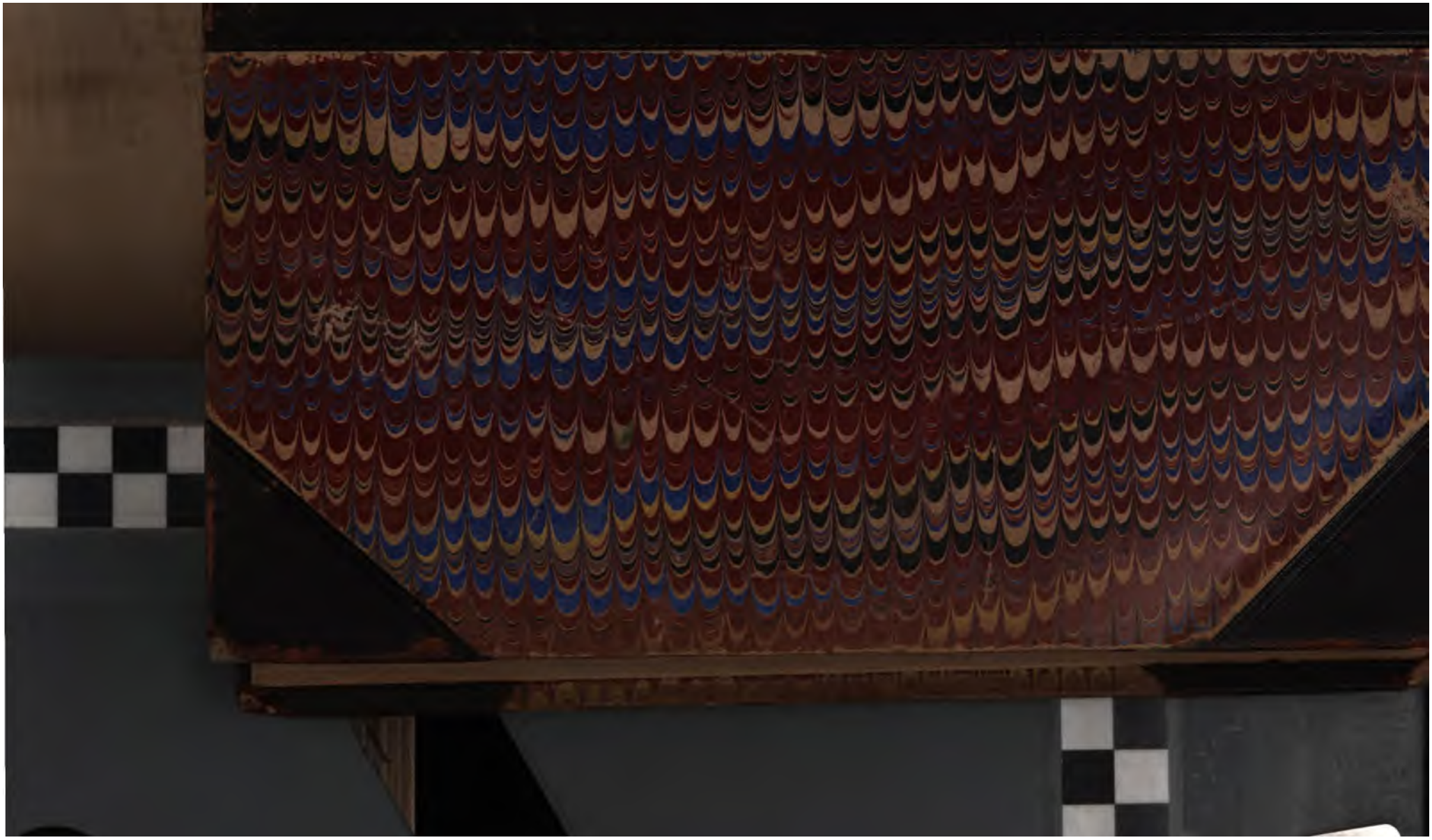
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